THE SOLDIER'S LOAD AND THE MULTIFUNCTIONAL UTILITY/LOGISTICS AND EQUIPMENT-TRANSPORT

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14. ABSTRACT

The weight of the loads carried by today's dismounted infantrymen has degraded their ability to operate in restricted terrain. This degradation in capability has had a drastic impact on the effectiveness of the Infantry Brigade Combat Teams which were designed to operate in restrictive and severely restrictive terrain. Originally developed as a part of the Future Combat Systems program, the Multifunctional Utility/Logistics and Equipment–Transport is an unmanned ground vehicle designed to carry some of the excess weight of the rifle squad. This research project sought to determine whether or not the Multifunctional Utility/Logistics and Equipment–Transport is a viable mitigation strategy for the Soldier load problem in the Infantry Brigade Combat Team. The study defined the severity of the Soldier load problem as well as the capabilities and limitations of the Multifunctional Utility/Logistics and Equipment–Transport. Given a notional mission in jungle, urban, and mountainous terrain, the Multifunctional Utility/Logistics and Equipment–Transport was assessed against a set of evaluation criteria which included mobility, versatility, and protection. That assessment led to the conclusion that the MULE-T, as it is currently designed, is not a viable mitigation strategy for the Soldier's load problem in the Infantry Brigade Combat Team.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE SOLDIER'S LOAD AND THE MULTIFUNCTIONAL UTILITY/LOGISTICS AND EQUIPMENT-TRANSPORT, by MAJ John A. McLaughlin, 99 pages.

The weight of the loads carried by today's dismounted infantrymen has degraded their ability to operate in restricted terrain. This degradation in capability has had a drastic impact on the effectiveness of the Infantry Brigade Combat Teams which were designed to operate in restrictive and severely restrictive terrain. Originally developed as a part of the Future Combat Systems program, the Multifunctional Utility/Logistics and Equipment–Transport is an unmanned ground vehicle designed to carry some of the excess weight of the rifle squad. This research project sought to determine whether or not the Multifunctional Utility/Logistics and Equipment–Transport is a viable mitigation strategy for the Soldier load problem in the Infantry Brigade Combat Team. The study defined the severity of the Soldier load problem as well as the capabilities and limitations of the Multifunctional Utility/Logistics and Equipment–Transport. Given a notional mission in dessert, urban, and mountainous terrain, the Multifunctional Utility/Logistics and Equipment–Transport was assessed against a set of evaluation criteria which included mobility, versatility, and protection. That assessment led to the conclusion that the MULE-T, as it is currently designed, is not a viable mitigation strategy for the Soldier's load problem in the Infantry Brigade Combat Team.

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ACRONYMS

ANS	Autonomous Navigation System
BCT	Brigade Combat Team
BOIP	Basis of Issue Plan
DOTMLPF	Doctrine/Policy, Organization, Training, Materiel, Leadership, Personnel, Facilities
FCS	Future Combat Systems
FM	Field Manual
IBCT	Infantry Brigade Combat Team
kph	Kilometers per hour
MULE-T	Multifunctional Utility/Logistics and Equipment–Transport
ORP	Objective Rally Point
TRADOC	Training and Doctrine Command
UGV	Unmanned Ground Vehicle
UMS	Unmanned System

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CHAPTER 1

INTRODUCTION

> The machine has made warfare more ponderous but has also given it greater velocity. In the other direction there has been no change at all. For it is conspicuous that what the machine has failed to do right up to the present moment is decrease by a single pound the weight the individual has to carry in war. He is still as heavily burdened as the soldier of 1000 years B.C.
>
> —Marshall, *Soldier Load and the Mobility of the Nation*

Background

More than half a century after S.L.A. Marshall published the above quote in *The Soldier's Load and the Mobility of a Nation*, the U.S. Army initiated an acquisition program to develop a machine to decrease the individual load of the Soldier. The Multifunctional Utility/Logistics and Equipment–Transport (MULE-T) is an unmanned ground vehicle (UGV) designed to offload some of that burdensome weight of the modern Soldier's load. Originally established as a component of the Future Combat Systems (FCS) program, the MULE-T was developed by Lockheed Martin as a subcontractor to the FCS Lead Systems Integrators, Boeing and Science Applications International Corporation. The MULE-T was one of three MULE variants which were supposed to be designed around a common chassis called the Common Mobility Platform (see figure 1). The two other variants are a countermine variant called the Multifunctional Utility/Logistics Equipment-Countermine and an armed reconnaissance variant called the Armed Robotic Vehicle-Assault (Light). All three Lockheed Martin variants are designed to incorporate a mission specific package onto the common mobility platform. In contrast to the other two variants, the MULE-T possesses very limited mission specific equipment. It is basically the common mobility platform with a cargo deck and tie down fixtures attached to the top as well as a battery charger to support the rifle squad.

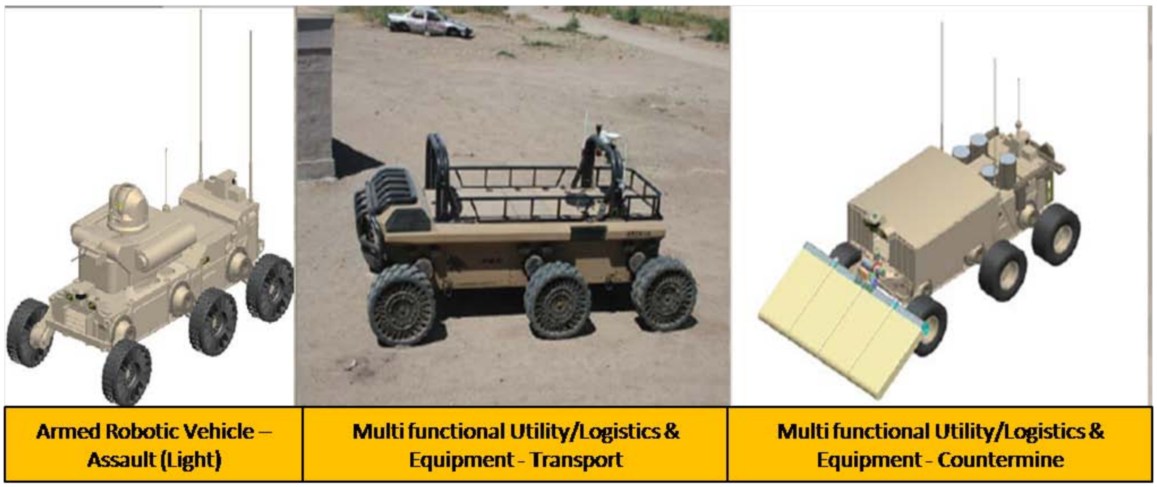

Figure 1. MULE Family of Vehicles
Source: U.S. Army, "Multifunctional Utility/Logistics & Equipment (MULE)," http://www.bctmod.army.mil/downloads/pdf/MULE_09-9077.pdf (accessed 27 April 2010).

To add to the magnitude of the problem discussed in *The Soldier's Load and the Mobility of a Nation*, the Soldier's load weight has nearly tripled in weight since the time when the book was published. Technological innovations have exponentially increased the lethality, protection, and survivability of the U.S. Army infantryman; however, they have also degraded the Soldier's mobility on the battlefield. In the recent conflicts in Iraq and Afghanistan, many leaders worry that the delicate balance between lethality, protection, and mobility is sliding away from mobility at the expense of mission accomplishment. The approach march load of a World War II Soldier was approximately 40 pounds (Marshall 1950, 72).

The approach march load of today's Soldier can exceed 171 pounds (U.S. House of Representatives 2009, 3). On 11 March 2009, General Peter Chiarelli, Army Vice Chief of Staff, in his testimony to the House Appropriations Committee's Subcommittee on Defense stated the fighting load weight as 63 pounds. He continued that the average Soldier load, consisting of the rucksack, weapon, ammunition, helmet, and other gear ranged from 63 to 130 pounds. The Individual Body Armor ranges from 26 to 41 pounds. The Vice Chief of Staff of the Army went on to reference a study which showed "that infantry Soldiers carrying a load of 101 pounds for 12.5 miles had a decrease of 26 percent in marksmanship (number of targets hit), a 33 percent increase in distance from the target center, and an increase in back pain compared to pre-load and march scores" (U.S. House of Representatives 2009, 3). General Chiarelli noted that the Army is seeking advanced technology solutions, such as unmanned platforms, as a course of action to mitigate the problem and restore Soldier mobility.

In a letter to S.L.A. Marshall, GEN J.F.C. Fuller wrote:

> The Soldier cannot be a fighter and a pack animal at one and the same time, any more than a field piece can be a gun and a supply vehicle combined. The idea is wrong at the start. Yet it is always being repeated. Fundamentally only two great novelties have come out of recent warfare. They are: (1) mechanical vehicles, which relieve the Soldier of equipment hitherto carried by him; (2) air supply, which relieves the vehicle of the road. (Marshall 1950, 20)

This study does not aim to prove that the MULE-T is a great innovation of war; rather it simply intended to determine if the MULE-T is a "modern cure for a problem as ancient as the history of war" (Marshal 1950, 23).

This study examined whether or not the MULE-T should be included in any of the increments of capability packages which will be fielded to the IBCTs. The system will clearly carry weight and therefore can reduce the Soldier's load. However, the capability to carry weight is not the only factor in deciding whether or not to field the MULE-T. The system must be able to be integrated into the formation without creating more problems than it solves. Simply put, no system is perfect, so it will be a question of managing risk. Do the rewards outweigh the risks? Any system added to the IBCT must be able to function in the operational environment in which the formation can expect to be deployed without significantly degrading its effectiveness in areas such as mobility, surprise, and survivability.

While all parties involved in the acquisition of Soldier equipment struggle to reverse the upward trend of the Soldier's load weight, technological and financial limitations will only warrant limited near term progress. As a midterm mitigating solution, the Army is exploring the use of unmanned systems to offload some of that weight. Although the MULE-T survived a Secretary of Defense decision to terminate the FCS program in 2009, the Army later terminated the system in January 2010 (Tiron 2010). The Army's decision to terminate the MULE-T currently leaves it with no programs of record to mitigate the weight of the Soldier's load.

Primary Research Question

Is the MULE-T a viable mitigation strategy for the Soldier load problem in the Infantry Brigade Combat Team (IBCT)?

Secondary Research Questions

The following secondary research questions will support the primary question. The first question sought to determine if the current approach march load weight carried by the average infantryman in an IBCT degrade combat effectiveness. The next question examined what were the capabilities needed for a UGV to be a viable material solution to the Soldier load challenge given the operating environment in which the IBCT typically fights. The third secondary research question asked if the capabilities and specifications of the MULE-T met the needs of the IBCT. If not, what changes should be made to its requirements to optimize the system for the IBCT?

Definition of Key Terms

Approach March Load. An approach march load is the load that the Soldier carries in addition to his fighting load. These items are dropped in an assault position, ORP [Objective Rally Point], or other rally point before or upon contact with the enemy. On long dynamic operations, Soldiers must carry enough equipment and munitions to fight and exist until a planned resupply can take place. These loads vary and may exceed the goal of 72 pounds (Headquarters, Department of the Army 2006b, 11-7).

Combat Load. A combat load consists of the minimum mission-essential equipment, as determined by the mission commander. This includes only what is needed to fight and survive immediate combat operations. The two levels of combat load are (1). fighting loads, which are carried on dynamic operations where contact with the enemy is expected, and (2). approach march loads, which are carried when transportation cannot be provided for equipment over and above fighting loads (Headquarters, Department of the Army 2006b, 11-6).

Fighting Load. A fighting load is what the Soldier carries once contact has been made with the enemy. It consists only of essential items the Soldier needs to accomplish his task during the engagement. For close combat and operations requiring stealth, any load at all is a disadvantage. Cross loading of machine-gun ammunition, mortar rounds, antitank weapons, and radio equipment causes most combat loads to exceed 48 pounds. This is where risk analysis is critical. Excessive combat loads of assaulting troops must be configured so that the excess can be redistributed or shed (leaving only the fighting load) before or upon contact with the enemy (Headquarters, Department of the Army 2006b, 11-7).

Leader Follower. The capability of an unmanned ground vehicle (UGV) to traverse a safe and tactically relevant route previously traversed. The follower vehicle traverses the route automatically (i.e., under computer control using onboard sensors) potentially with significant physical or temporal separation from the leader. This capability takes advantage of human sensing and reasoning in the lead vehicle to reduce the perception and intelligence requirements for the follower vehicle. The follower vehicle may incorporate some limited perceptual capabilities to detect and avoid new obstacles that appear after the lead vehicle has passed (National Institute of Standards and Technology 2004, 17).

Overwatch. The tactical role of an element positioned to support the movement of another element with immediate fire (Headquarters, Department of the Army 2004, 1-142).

Semi-Autonomous. A mode of operation of a UMS wherein the human operator and/or the UMS plan(s) and conduct(s) a mission and requires various levels of human-robot interaction (National Institute of Standards and Technology 2004, 14).

Teleoperation. A mode of operation of a UMS wherein the human operator, using video feedback and/or other sensory feedback, either directly controls the actuators or assigns incremental goals, waypoints in mobility situations, on a continuous basis, from off the vehicle and via a tethered or radio linked control device. In this mode, the UMS may take limited initiative in reaching the assigned incremental goals (National Institute of Standards and Technology 2004, 14).

Unmanned Systems (UMS). An electro-mechanical system, with no human operator aboard, that is able to exert its power to perform designed missions. May be mobile or stationary. Includes categories of unmanned ground vehicles (UGV), unmanned aerial vehicles, unmanned underwater vehicles, unmanned surface vehicles, unattended munitions, and unattended ground sensors. Missiles, rockets, and their submunitions, and artillery are not considered unmanned systems (National Institute of Standards and Technology 2004, 20).

Limitations

The study relied on information that was available through unclassified sources. This study looked at the loads carried by infantrymen in the IBCTs. As the aforementioned definitions of the various loads suggests, the mission commander's discretion plays a significant role in which items comprise each load. In order to provide a fixed figure, this study utilized the weight estimates provided by the Maneuver Center of Excellence and General Chiarelli during his 2009 testimony before Congress on Soldier equipment ergonomics. Based on those figures and the operational environment in which the IBCT is expected to fight, the study examined whether or not fielding the MULE-T is a viable mitigation strategy to lighten the Soldier's load in the IBCT.

Delimitations

This study did not examine the Soldier load problem as it exists in other brigade combat teams (BCTs). Several solutions exist and are being pursued across the doctrine/policy, organization, training, materiel, leadership, personnel, and facilities (DOTMLPF) domains; however, this study only focused on the ability of the MULE-T to mitigate the capability gap. It did not look at any other DOTMLPF solutions; nor did it evaluate the viability of other materiel solutions besides the MULE-T. Although this study did research the capabilities and limitations of other unmanned solutions, it was not done in an evaluation mode. Rather research on other unmanned solutions was used to help determine the evaluation criteria to allow for a more informed assessment of the MULE-T.

This study did not examine the use of pack animals to mitigate the Soldier load problem. Although this technique has been used with varying degrees of effectiveness in Iraq and Afghanistan, it requires excessive internally provided manpower, is not easily deployed with a BCT, and is dependent upon each operating environment. For example, in some environments a camel may be ideal whereas a donkey may be ideal in others. This disparity causes an excessive training and readiness burden on IBCTs.

This study did not examine the use of human powered carts since the number of Soldiers required to pull the carts would need to be internally provided and would greatly reduce the number of available infantrymen serving as trigger pullers. For many of the same reasons listed above, this study did not examine manned materiel solutions. Manned vehicles would require a higher number of Soldiers to operate the vehicles than a UGV and also expose the operators to higher risks from improvised explosive devices and direct fire contact.

Due to financial and security implications, this document did not provide any detailed information which might violate the proprietary rights of the associated manufacturers or jeopardize the sensitivity of pertinent government documents and specifications. Much of the detailed data that is needed to support a decision to field the MULE-T, or any defense program, is deemed proprietary in order to protect the intellectual property and effort of the manufacturers. As previously stated, this thesis is focused on the requirements and conceptual employment of the MULE-T. The lack of specific performance and design data associated with the MULE-T would need to be assessed by a larger and more qualified study.

Assumptions

The U.S. Army will not motorize the infantry rifle companies of the IBCT with wheeled vehicles such as Mine Resistant Ambush Protected Vehicles, High Mobility Multipurpose Wheeled Vehicles, or Joint Lightweight Tactical Vehicles. Further, the Army will not support adding more personnel to the IBCT formation to serve a drivers or gunners for additional vehicles, whether issued as a modified table of equipment item or theater provided equipment.

Significance

In June of 2009, the Department of Defense cancelled the FCS program. In the aftermath of this cancellation, the Army is in the process of redefining its modernization strategy. While some of the unmanned systems being developed under the FCS program have survived and are scheduled to be fielded to IBCTs beginning in 2011, the fate of the MULE-T was not decided until January 2010. At that point, the Army made the decision to cancel the system; however, the Soldier's load capability gap still exists. This study, sought to use the recent cancellation of the MULE-T as an opportunity to tactically analyze the MULE-T as both a system and a concept and, if necessary, recommend changes before the Army's Training and Doctrine Command (TRADOC) releases its next round of requirements documents. The release of those documents is expected to begin this year when the Army's Capabilities Integration Center takes the Initial Capabilities Document for Unmanned Systems to the Joint Requirements Oversight Council for approval (Censer 2010). This study examined if the MULE-T, a system designed for this exact problem but for a different BCT, should be fielded to the IBCTs. If not, then the issue becomes what requirements should be adjusted to tailor the system, or future systems, for the IBCT.

CHAPTER 2

REVIEW OF LITERATURE

The purpose of this research project was to determine if the MULE-T is a viable mitigation strategy for the Soldier load problem in the IBCT. The purpose of this chapter is to review the literature pertinent to the Soldier's load, UGVs, and the tactical mobility of light infantry forces. There are four major sections within this chapter. The first section, background, sources discuss the basis for the Soldier's load issue. The second section, doctrine, discusses current U.S. Army doctrinal references pertaining to Soldier's load. The third section, studies, reviews the various studies which have been conducted in this field to date. The final section, special considerations, incorporates recent lessons learned on small unit operations in Iraq and Afghanistan.

Background

The Soldier's Load and the Mobility of a Nation is considered to be the key study of Soldier load and its impact on unit effectiveness. Although the study is based on World War II data, the analysis is still relevant today and is the foundation of both Marine and Army doctrine on the topic and is quoted in almost any work on the topic. The three main topics from Marshall's work were used to guide this research project. The first topic is the load carrying limits of the Soldier. The second is the spiraling impacts of fatigue on fear. The third is the relationship between the Soldier's load and combat effectiveness.

Marshall attempts to show that "there can be true economy of men's powers in war only when command reckons with man as he is and not as it would like him to be" (Marshall 1950, 22). In this work S.L.A. Marshall provides a mathematical framework for determining the proper load for each Soldier to carry. Marshall suggests that 33 percent of a Soldier's body weight is the optimal load size (Marshall 1950, 70). This suggested load ceiling aims to prevent harm to the mental powers as well as bone and muscle and is still widely accepted. For example, TRADOC Pamphlet 525-66, *Force Operating Capabilities*, provides conceptual statements which describe what the senior leadership of TRADOC believes are essential warfighting capabilities for the future force. This document harkens back to Marshall and states that in order to "achieve revolutionary effectiveness across the full spectrum of conflict" the Army must "reduce Soldier dismounted movement approach load to no more than 40 pounds" and "reduce dismounted Soldier's fighting load to 15 pounds" (TRADOC 2008, 158).

Marshall also notes that tired Soldiers are more susceptible to fear. He points out that "whatever wears out the muscles reacts on the mind and whatever impairs the mind drains the physical strength" (Marshall 1950, 46). Once fear sets in, their physical strength drains more rapidly, creating an exponential degradation in the Soldier's effectiveness (Marshall 1950, 46-47). Thus overburdening Soldiers initiates a cycle of fear and fatigue which diminishes the Soldier's physical capacity to fight.

When Soldier mobility is degraded due to excessive loads, it is not solely his offensive ability which is diminished. The biology behind the physical exhaustion not only drains the bodily fluids, but it also attacks the nervous system. The mental and moral exhaustion which accompanies the physical exhaustion degrades the Soldier's ability to defend himself rendering him combat ineffective (Marshal 1950, 48-50). The weight on the Soldier's back degrades his security as well as his mobility.

The three key points discussed helped develop the foundation for this study. It highlighted the potential for the MULE-T to do more than just improve individual mobility. According to Marshall, if the MULE-T is able to reduce the Soldier’s load it can improve his overall combat effectiveness thereby increasing the proficiency of the platoon as a collective warfighting instrument. The next section will discuss the current Army doctrinal references pertinent to this research project.

Doctrine

To understand the issues of the Soldier’s load and the tactical mobility of light infantry, it is important to understand the doctrinal framework of the two subjects. The four most pertinent Army doctrinal references are Field Manual (FM) 3-21.8, *The Infantry Rifle Platoon and Squad;* Field Manual (FM) 3-21.10, *The Infantry Rifle Company;* FM 3-90.6, *The Brigade Combat Team* (2006a); and FM 21-18, *Foot Marches.*

Field Manual (FM) 3-21.10, *The Infantry Rifle Company*, and FM 21-18, *Foot Marches*, are the principal doctrinal references in the Soldier load field. Based on Marshall’s research, FM 3-21.10, *The Infantry Rifle Company*, frames the optimal fighting load of the Soldier as 30 percent of body weight and that the approach march load should not exceed 45 percent of his body weight. FM 3-21.10, *The Infantry Rifle Company*, goes on to say that once a Soldier carries more than 45 percent of body weight, functional ability drops rapidly, and chances of becoming a casualty increase. FM 21-18, *Foot Marches*, adds that “the time a Soldier needs to complete an obstacle course is increased from 10 to 15 percent, depending on the configuration of the load, for every 10 pounds of equipment carried” (Headquarters Department of the Army 1990, 5-4). When

FM 21-18, *Foot Marches*, was published in 1990, the authors came to the realization that Soldier load can only be reduced by sending Soldiers into combat inadequately equipped or by providing a capability to help them carry the required equipment. Twenty years later, we have still neither heeded the authors' conclusions, nor have we completed research that disputes their recommendations.

Beyond providing doctrinal references for the Soldier's load, these field manuals also provide the framework for how light infantry units operate. This framework was important in order to ensure that the integration of a MULE-T did not diminish the strengths and capabilities which these formations rely upon. FM 3-90.6, *The Brigade Combat Team*, highlights that in the current operational environment, enemy forces rely on restrictive and severely restrictive terrain, such as urban areas, to neutralize the firepower advantages of the U.S. military. Therefore, maneuver forces must be optimized for operations in mixed terrains (2006a, xviii). The field manual goes on to highlight that the versatility of the IBCT is what separates it from the other BCTs (Headquarters Department of the Army 2006a, A-6). It must be equally adept across the range of operations, in all types of terrains, and against all types of enemy forces.

Although FM 3-90.6, *The Brigade Combat Team*, provides one of the most current doctrinal reference to the need for mobile, light infantry formations in modern warfare, it is hardly a new concept. In 1984, General John A. Wickham, Chief of Staff of the Army, published the "Light Infantry Divisions: White Paper 1984" which outlined the direction for the creation of light infantry divisions. The new light infantry divisions, much like today's IBCTs, were built to provide a rapidly deployable force which was mobile, lethal, and versatile enough to defeat any foe in any terrain. Basically, the intent was to enhance the strategic and tactical mobility of the Army through the employment of light infantry (Wickham 1984, 1-5).

Since the focus of this research project was the platoon, FM 3-12.8, *The Infantry Rifle Platoon and Squad*, was another instrumental doctrinal reference. This manual begins by acknowledging that one of the three vulnerabilities of the infantry is the conflicting nature of ensuring the infantryman carries all that is needed to accomplish the mission and preserving his physical ability to fight (Headquarters Department of the Army 2007, 1-1). This manual also references the core components of close combat. These components include firepower, mobility, and protection. As has been reinforced throughout military history, successful units must not only be proficient in all three components, but they must also understand the delicate balance which exists among the components (Headquarters Department of the Army 2007, 1-6). The need to leverage these components in unison to win on the battlefield inspired the creation of the evaluation criteria used during this research project.

Studies

The publication of General Wickham's "Light Infantry Divisions: White Paper 1984" and the subsequent fielding of the light infantry divisions energized a generation of Army officers at the Command and General Staff College and War College to focus their research endeavors on the topic of light infantry on the modern battlefield. Three of these works helped to inform the needs of a light infantry formation and the impacts the MULE-T may have on such a formation. Franklin L. Hagenbeck, then a Lieutenant Colonel at the United States Army War College, examined the shortcoming of the light infantry divisions in "The Light Infantry Division: A Case for Greater Robustness in a

Downsized Army." Two of the shortcomings he cites are the impacts of carrying rucksacks in excess of 100 pounds and a lack of medical evacuation capabilities (Hagenbeck 1993, 15-16). Much like the impending political context of today, Hagenbeck conducted his study project with the backdrop of a resource constrained environment and a call to shrink defense spending.

Two of these documents recommend augmenting the light infantry force to improve the tactical and operational mobility of the formation. In "The Soviet BTR on the Modern European Battlefield: Does It Have a Place in the U.S. Army's Light Infantry," Major Richard L. Elam examined and advocated adding the BTR, a Soviet wheeled troop transport vehicle, to the light infantry formation (Elam 1990). In "The Light Infantry Company and Tactical Mobility: A Step in Which Direction?," Major John M. Spiszer advocated adding High Mobility, Multipurpose, Wheeled Vehicles to light infantry companies to alleviate what he described as a serious shortfall in tactical mobility (Spiszer 1997).

The Command and General Staff College provided a fourth document which was influential in the conduct of this research project. "Tactical Mobility of the Medium Weight Force in Urban Terrain" studied the employment of the Interim BCT, now called the Stryker BCT, in a modern urban environment. Although the author, Major Scott C. Johnson, does not speak specifically to light infantry operations he does offer a detailed account of the characteristics of an urban environment and its impacts on vehicular movement. This work, in conjunction with Robert Kaplan's *The Coming Anarchy*, was used to guide the evaluation of the MULE-T against operations in urban terrain.

Special Considerations

The emphasis on restoring tactical mobility and reducing Soldier load is not isolated to previous generations or schoolhouse research, nor has it been refuted by the wars in Iraq and Afghanistan. As tactical after action reports have emerged from both theaters, the issue has once again been raised by leaders of maneuver forces at all levels. In the July 2009 edition of *Infantry*, two articles highlighted the need to emphasize and improve dismounted mobility.

Major Joseph Labarbera and Captain Rob Newsome drew from their operational experiences to confirm many of the ideas posed in *The Soldiers Load and the Mobility of a Nation*. The authors note that in the current counterinsurgency fight, enemy forces rely on non-permissible terrain to establish safe zones because these areas are not accessible to coalition tracked or wheeled vehicles. Therefore, coalition forces must project combat power via dismounted patrolling. In order to successfully project that combat power, units must first overcome the Soldier load obstacle. Labarbera and Newsome note that when dismounted forces are able to offload some of their weight, the stealth and speed they gain often improves their survivability more than their body armor (Labarbera and Newsom 2009, 11). However, the authors also warn against the reliance on vehicles to support dismounted operations. The rationale behind their cautionary notes includes a tendency to plan around the support vehicles as opposed to the dismounted patrol, a mental reliance on the support vehicle, loss of stealth, and the combat power which must be dedicated to defending these vehicles when they are staged at the objective rally point (Labarbera and Newsom 2009, 12). Although their cautions were written in reference to the manned ground vehicles used in theater, their premises still ring true.

In the same issue of *Infantry*, Captain Aaron W. Childers and Sergeant First Class David Banks detail the importance of dismounted patrolling in Afghanistan as well as the challenges of vehicular movement. While the authors echo many of the previous arguments for the value of dismounted patrolling, they also describe the terrain in Afghanistan from the perspective of tactical patrol leaders. These descriptions were used to guide the evaluation of the MULE-T against operations in mountainous terrain.

Childers and Banks also highlight two of the emerging and most challenging issues associated with Soldiers load: batteries and communications. As technologies have increased the range of the influence of units, units have been forced to assume responsibility for larger areas of operations. Most, if not all, of these technologies rely on batteries (Childers and Banks 2009, 38). The cumulative effects of batteries are increasingly accounting for a much higher percentage of the overall Soldier load. As the areas of operations have grown, it has also expanded the communications challenges unique to the small units of the IBCT (Childers and Banks 2009, 38). They also discuss the challenge of how small units communicate with a higher headquarters which is increasingly further away, without the luxury of vehicle borne power amplifiers? Both these issues were considered during the evaluation of the MULE-T.

Like Marshall, Childers and Banks also highlight the associated psychological effects. However, in this case the authors discuss the psychological effects dismounted patrolling had on the population they were trying to secure and influence. Both note that when the unit began dismounted patrols the Afghan population treated them with greater hospitality. When questioned, the Afghans attributed the shift in atmospherics to the fact that unlike previous Coalition or Soviet units, the unit reduced the barrier between the two groups by ditching their vehicles (Childers and Banks 2009, 37).

However, *Wired for War* cautions that the use of UGVs to achieve these effects may also have unintended psychological consequences on our adversaries or even the civilian populace at large. Peter Singer points out that these systems may embolden our adversaries and further distance us from the populace. Many people will interpret an increased use of robots as an act of cowardice, especially in cultures which hold in high esteem the nobility of sacrificing oneself for a higher purpose (Singer 2009, 312).

Summary

This chapter provided a review of the literature related to this research project. The review of literature established a linkage between the weight of the Soldier's load and success on the battlefield. However, the Army must be cognizant of the risk associated with the methods employed to increase tactical mobility. This chapter also provided the doctrinal references, studies, and recent lessons learned which helped shape the Soldier's load and tactical mobility discussions. Although the amount of literature available on UGVs is limited, authors such as Peter Singer have begun to highlight the need for further study in this field. The data provided by these sources were the foundation for the research methodology as it is laid out in the next chapter.

CHAPTER 3

RESEARCH METHODOLOGY

Introduction

The purpose of this research project was to determine if the MULE-T is a viable mitigation strategy for the Soldier load problem in the IBCT. The purpose of this chapter is to describe the research methodology used to determine whether or not the MULE-T's capabilities and limitations would enable the system to be integrated into the IBCT to alleviate the Soldier load problem. The chapter is comprised of four sections. The first section, methodology, provides an overview of the type of research methodology employed during this research project. The second section, data, discusses the two main sources of data which were generated. Following that, the procedures section provides the sequential details of how the research project was executed. Finally, the analysis section reviews the manner in which the narrative data was organized and interpreted to produce finding, recommendations, and conclusions.

Methodology

The research project followed a qualitative research methodology (Creswell 2007). Qualitative research uses inductive document analysis to establish patterns and themes which allow for complex description and interpretation of the problem (Creswell 2007, 37). A qualitative research methodology was chosen because it affords a detailed, multifaceted understanding of the issue (Creswell 2007, 40).The document analysis was based on two primary sources of narrative data in order to ascertain a preponderance of evidence present in the emergent patterns or themes. The qualitative research of the two data sources, which will be discussed in the subsequent section, answered the four secondary research questions discussed in the first chapter of this document.

Data

As mentioned in the previous section, this research project was built upon the document analysis of two primary sources of data (Patton 2002, 4). These two sources of data are discussed in detail within this section. The first source of data was developed through analysis of the doctrine and literature available on the topics of Soldier's load, UGVs, and the tactical mobility of light infantry forces. The second source of data was developed through the execution of a series of tactical scenarios.

The first source of data used in this research project was based on analysis of doctrine and other literature available on the topics of Soldier's load, UGVs, and the tactical mobility of light infantry forces. The sources of this data were discussed in the previous chapter. Those sources included a review of infantry doctrine, past studies on Soldier's load and tactical mobility, capability development documents, and performance based assessments of light infantry forces and UGVs. The narrative data obtained during the literature review was used to determine if the current approach march load carried by the average infantryman in an IBCT degraded combat effectiveness. The data was then used to determine which capabilities were needed for the MULE-T to be a viable material solution to the Soldier load challenge in the IBCT. Those capabilities and other narrative data were used to inform the development of the tactical scenarios and evaluation criteria which were used to determine if integrating the MULE-T into the IBCT would achieve the desired endstate.

The second source of data used in this research project was derived from the execution of an infantry rifle platoon mission. The mission used in this study revolved around an IBCT infantry rifle platoon conducting a typical platoon attack (see figure 2). The infantry rifle platoon was comprised of three rifle squads, a weapons squad, and a headquarters element. The infantry rifle platoon was augmented with two MULE-Ts for the mission. The MULE-Ts were operated by two trained operators provided by the company headquarters section in support of the operation. These operators were task organized to the platoon headquarters section (Maneuver Battle Lab 2009, 118).

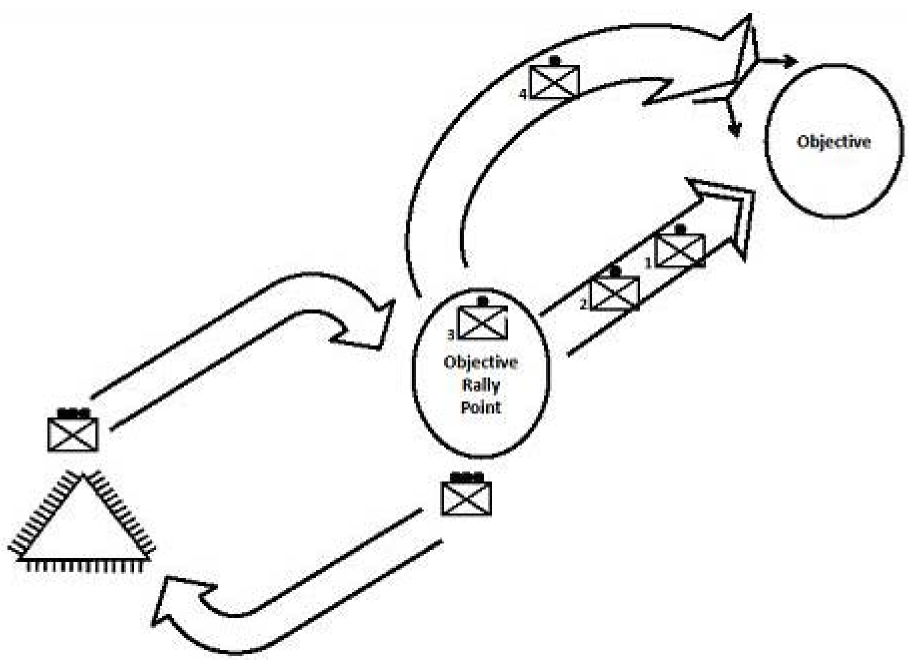

Figure 2. Mission Overview
Source: Created by author with graphics from Headquarters, Department of the Army, Field Manual (FM) 1-02, *Operational Terms and Graphics* (Washington, DC: Government Printing Office, 2004).

The basis of issue plan (BOIP) was two MULE-Ts per platoon in order to mirror the most updated Unit Reference Sheet developed for the FCS BCT (Unit of Action Maneuver battle Lab 2006, E-2-B-2). The FCS BCT was developed to more closely resemble a Heavy BCT than an IBCT. However, a BOIP analysis was not done to determine how many, if any, MULE-Ts would be fielded to each IBCT platoon. Although the FCS BCT BOIP may not match a BOIP developed specifically for an IBCT, the FCS BCT BOIP was used to guide the development of the MULE-T. Therefore, the MULE-T was designed to carry two squads worth of equipment. Since this study sought to examine the requirements base of the MULE-T, the BOIP logic was carried forward to the development of the mission.

The infantry platoon deployed on the dismounted operation from a company combat outpost to conduct an attack to clear insurgent forces operating in a given area. Like many infantry operations, the majority of the mission was spent in tactical movement phase of the operation. "Tactical movement is the movement of a unit assigned a tactical mission under combat conditions when not in direct ground contact with the enemy" (Headquarters, Department of the Army 2007, 3-1). The evaluation of the MULE-T focused primarily on the tactical movement conducted during the mission.

Prior to arriving at the platoon's objective, the platoon leader established an objective rally point (ORP). An ORP is a "point out of sight, sound, and small-arms range of the objective area" (Headquarters, Department of the Army 2007, 9-6). While at the ORP, the platoon leader decided to leave the unit's approach march load, consolidated on the two MULE-Ts, and proceeded to the objective with only their fighting load. This was done to improve tactical mobility; however, it required a security element remain at the

ORP to provide security. During the mission, the task of securing the ORP was assigned to one of the rifle squads.

Upon departing the ORP, the platoon divided into an assault and support by fire element. The support by fire element consisted of the weapons squad which provided suppressive fires to facilitate the clearance of the objective by the assault element. The assault element consisted of two rifle squads which simultaneously cleared the objective area of insurgent forces and caches. Once the objective was cleared, the platoon consolidated, reorganized, and initiated movement back to the ORP to link up with their equipment and the security element. The platoon linked up at the ORP and executed another tactical movement back to the combat outpost.

The mission described above and depicted in figure 2 intentionally omitted terrain from the background. Additional data for this research project was generated by examining how the MULE-T performed in various terrains in which the IBCT was designed to operate. The IBCT was developed specifically to operate in restrictive terrain (Headquarters, Department of the Army 2006, A-4). The terrain types selected were urban, mountainous, and jungle terrain. The terrain types were chosen because each represents a challenging type of restrictive terrain. In addition to the doctrinal basis, the mountainous and urban terrain chosen also reflect the predominant types of terrain in the two theaters in which the IBCTs are currently deployed. Although the IBCT is not currently deployed in jungles, our history does include operational experiences in theaters such as Vietnam which highlight a need to sustain such a capability.

The scenario employed during this research project was a gross generalization of the actions and planning involved in a platoon attack. However, it provided a sufficient mechanism to organize the narrative data collected during the qualitative research. It also served as a valuable reference point when evaluating the MULE-T in a tactical environment. This research project focused on the performance of the MULE-T at the tactical level. By focusing on the tactical level, the research project was able to examine and assess the capabilities and limitations of the system and how the system impacted the unit which it was designed to support.

The narrative data generated during the literature review and the scenario formed the foundation upon which this research project was constructed. However, these two sources produced an extremely large amount of data. The following section will discuss the procedures employed to translate the data into new knowledge.

Procedures

This research project was comprised of six steps. This section provides a sequential overview of those steps. The first step in the research project was to analyze the narrative data generated during the literature review. The analysis of the narrative data was then used to create a generic concept of the operation for a tactical mission. The mission was then combined with the terrains described in the previous section to form three separate tactical scenarios. Next, the platoon executed the tactical scenarios with two MULE-Ts which were assigned from the company. Each of the three executions of the scenario generated a separate data stream. The data streams on the MULE-T were then analyzed according to three evaluation criteria which included mobility, protection and versatility. The criteria are described in further details in the subsequent sections of this chapter. That analysis produced a series of findings. Finally, the analysis of the findings was used to answer the primary research question and generate recommendations for action and further study.

Analysis

This section will examine methods employed to analyze the narrative data generated during the tactical scenarios. The MULE-T was assessed according to the three evaluation criteria listed in table 1. The evaluation criteria were selected to represent the critical capabilities needed to accomplish the IBCT's mission without degrading its unique characteristics as listed in FM 3-90.6, *The Infantry Rifle Company*, and FM 3-21.8, *The Infantry Rifle Platoon and Squad*. As the platoon progressed through each of the three tactical scenarios with the assigned MULE-Ts, the system's performance data was recorded. That data was then assessed against the evaluation criteria.

The evaluation criteria were scored according to a green, amber, red rating system and recorded in a consolidated assessment table (see table 1). A green assessment indicated that the MULE-T exceeded the evaluation criteria. An amber assessment meant that the MULE-T met the evaluation criteria. Finally, a red assessment meant that the vehicle failed to meet the evaluation criteria. The following sections describe the evaluation criteria in greater details to include their definition, issues that factored into the assessment, and why that evaluation criterion was selected.

Table 1. Blank Consolidated Assessment Table			
Evaluation Criteria Title	Urban Scenario	Jungle Scenario	Mountain Scenario
Mobility			
Protection			
Versatility			

Source: Created by author.

Mobility

The mobility criterion was defined as the platoon's ability to move from place to place without additional delays due to terrain or obstacles, while retaining the unit's ability to accomplish its mission (Headquarters, Department of the Army 2004, 1-127). The mobility criterion was selected because it represents the other side of the problem statement. The remainder of this section provides further details regarding the factors which supported the assessment of the mobility criterion.

Table 2. Mobility Evaluation Criterion Factors	
MULE-T Performance Factors	Unit Mobility Factors
• Off road capability • Turning radius • Fording ability • Gap crossing capability • Speed • Slope • Additional capabilities	• Payload • Rate of march

Source: Created by author.

As previously discussed, the current weight of the Soldier's load has reduced the mobility of the dismounted infantrymen. Reducing that weight by transferring equipment to the MULE-T will improve the tactical mobility of the Soldier. However, the mobility evaluation criterion also reflected the impact that the MULE-T will have on the formation as it executed tactical movements. Therefore, the factors which impacted the mobility criterion can be categorized as either MULE-T performance characteristics or affects it had upon the unit's mobility.

The MULE-T's performance characteristics which factored into the mobility criterion included the vehicle's off road capability, turning radius, fording ability, gap crossing capability, cross country speed, slope, as well as additional capabilities. The off road capability of the system referred to its ability to traverse the terrain relevant to each of the tactical scenarios. The turning radius was measured by the distance which the vehicle required to reverse direction, 180 degrees. If a unit is forced to change course this performance characteristic becomes important, especially when operating in an urban environment highlighted by narrow streets and alleys. The turning radius standard was established at one and a half times the vehicle's length (Unit of Action Maneuver Battle Lab 2006, D-6).

Gap crossing was particularly important in the jungle and mountainous terrains which were interspersed with wadis, streams, creek beds, irrigation ditches, and other natural or manmade obstacles. Gap crossing addressed two similar yet distinct capabilities: wet gap crossing and dry gap crossing. Wet gap crossing examined the MULE-T's ability to ford a shallow body of water. The wet gap crossing standard for this research study was one meter (Johnson 2001, 19). Dry gap crossing addressed the ability to cross a linear obstacle of up to one and a half meters, such as trenches, without assistance or preparation of the crossing site (Unit of Action Maneuver Battle Lab 2006, D-7). Therefore, wet gap crossing focused on the ability to drive through an obstacle while dry gap crossing focused on the ability to drive over an obstacle.

For the purposes of the mobility evaluation criterion, speed was defined as the rate at which the system was able to travel across complex terrain. The standard for speed was set at eight kilometers per hour (kph) across complex terrain. The standard was established to allow the vehicle to traverse complex terrain at a pace twice as fast as the dismounted unit it was supporting (Unit of Action Maneuver Battle Lab 2006, E-2-B-3).

Slope referred to the vehicle's ability to negotiate rises or falls in the surface upon which it is operating. Based on the terrain in which the IBCT operates, it included both front slope as well as side slope. Slope has always been important in determining a vehicle's ability to traverse hills or negotiate the banks or creeks or streams. Slope has also become particularly important in the arid and mountainous terrain of areas like Afghanistan. The dryness of these areas has forced many of the agrarian based communities to create extensive systems of irrigation ditches. In some instances these ditches can range from ten to thirty feet deep with five foot berms on either side (Childers and Banks 2009, 34). This terrain also highlights the importance of side slope. If the MULE-T is going to support dismounted movement in mountainous terrain it is necessary for the vehicle to be able to move vertically along the slope of the mountains and hills. The standard for slope was the capability to climb or descend a 60 percent slope in forward and reverse and laterally traverse a 30 percent slope (Unit of Action Maneuver Battle Lab 2006, D-5).

The additional capabilities factor was added to the evaluation criteria to expound upon the performance characteristics habitually discussed in vehicle acquisitions programs. The additional capabilities factor examined other capabilities which were required or designed into the vehicle which have second and third order effects upon the mobility evaluation criteria. Many of these capabilities, such as a battery charger, may be debated as the product of requirements creep; however, they each impacted the mobility of the platoon as a tactical formation.

The other half of the mobility criterion focused on how the MULE-T's capabilities and limitations impacted the unit's overall tactical mobility. Although, the previous factors all impact the unit, they can be assessed based solely on MULE-T performance. The following factors can only be measured when employed with the formation it is designed to support. The factors which drove this portion of the assessment included the payload and the Soldier's rate of march.

Payload was defined as the amount of equipment the MULE-T could carry. This evaluation criterion considered the weight the systems could carry and the cubic space where the equipment could be carried. Payload was selected as a factor since it ties directly back to the issue of the Soldier's load. The more equipment the platoon can place on the MULE-Ts, the lighter the individual Soldier's load will be, and the greater the increase in his combat effectiveness will be. Based on the Maneuver Center of Excellence's Soldier load data, the payload goal was set at 800 pounds (Barbero, Michael D. 2009, 63). This figure was determined by examining what equipment could be transferred to the MULE-T for a standard mission. The decision resulting in approximately a 45 pound reduction in the overall weight each Soldier had to carry.

Table 2 summarizes the factors which guided the assessment of the mobility criterion. Although there are clearly more factors from the MULE-T performance side of the coin, the heart of the evaluation criteria resided in the selected few unit mobility factors. Chapter 4 will discuss the relationship of these factors and the findings they produced. The next section details the protection evaluation criteria.

Protection

The following section defines the protection evaluation criteria and why it was chosen for this research project. The section also describes the factors which affected the assessment of the protection levels of a MULE-T equipped platoon. The factors included surprise, operator control, payload, and additional capabilities.

Table 3. Protection Evaluation Criterion Factors
• Surprise • Operator control • Payload • Additional capabilities

Source: Created by author.

The protection evaluation criterion was defined as the impact of the MULE-T on the unit's ability to preserve the force so the platoon leader could apply maximum combat power (Headquarters, Department of the Army 2008, 4-6). The criterion was chosen to address the safety of the unit when operating with the MULE-T. This criterion was designed to ensure that any increase in mobility did not come at the sake of unwarranted risk to the force.

The first factor which supported the protection evaluation criterion was surprise. Surprise was defined as allowing the unit to strike the enemy at a time or in a manner for which he is not prepared (Headquarters, Department of the Army 2004, 1-180). Surprise focused more on what effects the MULE-T had on the unit and the enemy during the conduct of the operation. It examined the MULE-T's ability to operate in all weather conditions as well as during periods of limited visibility. The system's ability to evade enemy visual and audio detection was considered in conjunction with the surprise factor.

The next factor considered was operator control. In reference to the protection criterion, operator control included the minimum control requirements needed to safely and effectively operate the MULE-T. The focus of this factor was control range and the level of autonomy. The standard for control range was set at two kilometers to support tactical separation between the UGV and the dismounted element it supported (Unit of Action Maneuver Battle Lab 2006, E-2-B-2). The system also had to be capable of being operated in the teleoperational and semi-autonomous control modes.

Payload was considered a factor under the protection criterion just as it was for the mobility criterion. However, as part of the protection criterion it focused on how the payload either improved or degraded to the unit's level of protection. Previous research by authors such as S.L.A Marshall discussed the linkages between Soldier load and security. This factor incorporated such impacts into the overall protection evaluation criteria.

As was the case for the mobility criterion, an additional capabilities factor was included in the protection evaluation criterion. The additional capabilities factor examined other capabilities which were required or designed into the vehicle. This factor captured the affects those capabilities had upon the assessment of the protection criterion.

The protection evaluation criterion, as described above, assessed the unit's ability to preserve the force during the execution of the tactical scenarios. The protection criterion was chosen to ensure that the MULE-T did not impose unnecessary risks upon the unit for the sake of improving mobility. Table 3 summarizes the factors which assisted in forming the overall assessment of the protection criterion. The next section will discuss the third and final evaluation criteria.

Versatility

The following section defines the versatility evaluation criteria and how it contributed to this research project. The section also describes the factors which affected the assessment of the versatility of a MULE-T equipped platoon. The factors included speed, operator control, range, and additional capabilities.

Table 4. Versatility Criterion Factors
• Speed • Operator control • Range • Additional capabilities

Source: Created by author.

FM 1-02, *Operational Terms and Graphics*, defines versatility as "the ability of Army forces to meet the global, diverse mission requirements of full spectrum operations" (Headquarters, Department of the Army 2004, 1-196). Although FM 3-0, *Operations*, rescinds the army definition of versatility, the spirit of the previous definition shaped the definition used during this research project (Headquarters, Department of the Army 2008, D-6).

In this study, versatility was defined as the unit's ability to adapt to diverse mission requirements and its flexibility to respond to an evolving situation. It was chosen in order to ensure a tactical formation maintained distinguishable characteristics. According to Army doctrine, the IBCT's is designed to be more versatile than the Heavy or Stryker BCTs (Headquarters, Department of the Army 2006a, A-6). As an integral part of the IBCT, the rifle platoon must be able to effectively adapt to "mixed terrain defense, urban combat, mobile security missions, and stability operations" (Headquarters, Department of the Army 2006a, A-6). Finally, the rifle platoon must be versatile enough to fight and win against conventional and unconventional forces during missions in support of operational maneuver or against insurgent threats (Headquarters, Department of the Army 2006a, A-6).

Like the mobility criterion, MULE-T speed was deemed an important factor in determining the versatility of the MULE-T equipped platoon. Although the definition and standard for speed did not deviate between the mobility and versatility evaluation criteria, the perspective upon which it was examined did. With respect to the mobility evaluation criterion, speed was merely judged in terms of keeping pace with the dismounted formation. However, when ascertaining its impact on unit versatility speed was examined in terms of the system's ability to move at a rate which facilitated various employment options for the platoon leader or platoon sergeant. For example, the speed factor analyzed the flexibility of the MULE-T to be displaced in a hide site and called forward as needed.

The second factor under the versatility evaluation criteria was operator control. The standard remained set at a minimum of two kilometer control range and the ability to operate in the teleoperational or semiautonomous control modes. However, this factor considered how the failure to meet or the ability to exceed those standards contributed to the degree of versatility inherent in the rifle platoon.

The next factor which influenced the versatility evaluation criteria was system range. Range was defined as “the distance which can be covered over a hard surface by a ground vehicle, with its rated payload, using the fuel in its tanks” (Headquarters, Department of the Army 2004, 1-156). This factor was incorporated because the system must be able to support the dismounted rifle platoon without imposing an additional logistics burden on the unit. It was assumed that the system would not be left running idle for any halts longer than the periodic security halts. Therefore the distance traveled was the unit of measure as opposed to total time it was operated. The standard for range was set at 65 kilometers so that the systems could support dismounted movement out to 32 kilometers and return to the start point (Unit of Action Maneuver Battle Lab 2006, E-2-B-3).

Once again, an additional capabilities factor was included in this evaluation criterion. The purpose of this factor remained indentifying capabilities which may impact the unit’s versatility. Under the versatility evaluation criteria, this factor focused on how much flexibility those capabilities provided to the unit. It also assessed the flexibility it afforded versus the penalty, if any, incurred to provide said capability.

The preceding section defined the final evaluation criterion, the protection criterion, and why it was chosen for this research project. The section also described the factors which affected the assessment of the versatility of a MULE-T equipped platoon. Those factors are listed in table 4.

Although some of the factors which drove each of the evaluation criteria may have been redundant, the manner in which they impacted the evaluation criteria distinguished them from each other. Additionally, each of the factors assumed varying degrees of importance during the three different scenarios. For example, the side slope the MULE-T was capable of traversing was a minor factor in the MULE-T's assessment during the jungle terrain, but was instrumental in assessing its performance during the mountainous scenario. When combined, the evaluation criteria examined if the MULE-T improved the mobility of the infantry rifle platoon and increased its versatility without degrading its protection to an unacceptable level.

Summary

This chapter outlined the qualitative research methodology employed during the study to determine if the MULE-T is a viable mitigation strategy for the Soldier's load problem in the IBCT. The requisite data to support the determination of the primary research question was derived from a review of the available literature on the Soldier's load, UGVs, and tactical mobility in the IBCT as well as the execution of three tactical scenarios. The performance of the MULE-T was recorded during the conduct of the urban, jungle, and mountain scenarios and analyzed according to the three evaluation criteria established for this research project: mobility, protection, and versatility. The results of each scenario and the findings generated during the study are described in the next chapter.

CHAPTER 4

FINDINGS AND ANALYSIS

Introduction

The purpose of this research project was to determine if the MULE-T is a viable mitigation strategy for the Soldier's load problem in the IBCT. The purpose of this chapter is to provide the findings of the qualitative research study which was detailed in the previous chapter. There are four major sections within this chapter. The first section, background, provides an updated status of the Soldier's load, its impact upon combat effectiveness, and the capabilities required of the MULE-T. The second section, scenario results, provides a record of what happened during the conduct of the three tactical scenarios. The third section, strengths and weaknesses, provides the strength and weaknesses of the MULE-T according to the evaluation criteria. The fourth and final section, findings, provides the analysis of the strengths and weaknesses described in the third section.

Background

This section encapsulates the latest data regarding the current weight that the average Soldier carries and the relationship between the weight of that load and the individual Soldier's combat effectiveness. The section also reviews the capabilities which the MULE-T must possess to be successfully integrated into the IBCT. That data will answer the first two secondary research questions and set the stage for the remainder of the research project.

As discussed in chapter 1, the problem facing infantrymen in the IBCT today is that the weight of the Soldier's load far exceeds the uppermost limits set forth in doctrine and previous research. Figure 3 is a depiction of the average Soldier's load in Iraq and Afghanistan provided by the Commanding General of the Maneuver Center of Excellence (Barbero 2009, 63). The data contained in figure 3 shows that the Soldier's load exceeds the doctrinal guidelines established for the approach march load by 60 pounds and the fighting load by 84 pounds (Headquarters Department of the Army 1990, 5-8). The weights listed in figure 3 are based on the rifleman's basic load, which accounts for only two of the nine members of the rifle squad. The squad leader, team leaders, anti-armor specialists, and grenadiers would all carry heavier loads due to the addition of communications equipment, heavier weapons, or ammunition. The same Soldiers may also be required to cross load special mission equipment such as litters, mortar rounds, and breaching kits in addition to their standard load. Special mission equipment for a squad can range up to 300 pounds (Unit of Action Maneuver Battle Lab 2006, E-2-B-2). If all of the Soldiers' loads mirrored the data in figure 3, the difference between the approach march load and the approach march load goal for a single squad would equal 546 pounds. When that figure is combined with the special equipment figures, the delta for two squads escalates up to approximately 1,993 pounds.

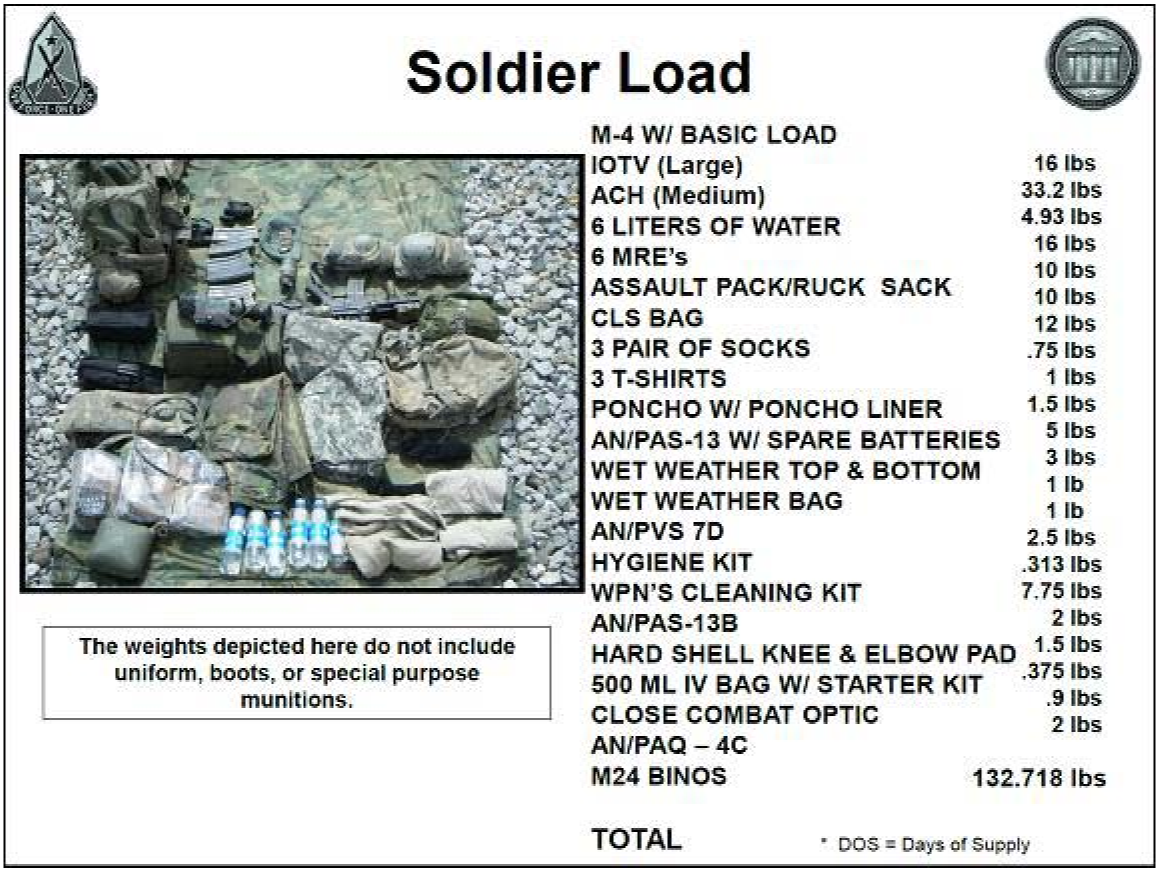

Figure 3. Soldier Load

Source: Michael D. Barbero, Major General, *Maneuver Center of Excellence Industry Day* (Briefing, Columbus Iron Works and Convention Center, Columbus, GA, 5 May 2009), 63.

A key component of this study involved finding links between the Soldier's load and combat effectiveness. The first secondary research question was whether or not the weight of the approach march load carried by the average infantryman in the IBCT degraded individual combat effectiveness. This research question was crucial because it served as a starting point for further research. If the Soldier's load does not hinder combat effectiveness, there is no need for the government to invest resources in the MULE-T. However, it also shaped the conduct of the research.

Previous research shows that if the individual load each Soldier carries is less than 30 percent of his body weight, he can generally maintain his mobility, agility, alertness, and stamina (Headquarters, Department of the Army 2006b, 11-4). Based on the weights depicted in figure 3, the current Soldier's load weight clearly surpasses the 30 percent threshold. Figure 4 shows the impacts of increased Soldier load weights upon the rate at which the Soldier can march, the distances covered, as well as his ability to negotiate an obstacle course. Furthermore, a separate study of infantry Soldiers carrying a load of 101 pounds for 12.5 miles, showed a 26 percent degradation in their marksmanship abilities (U.S. House of Representatives 2009, 3).

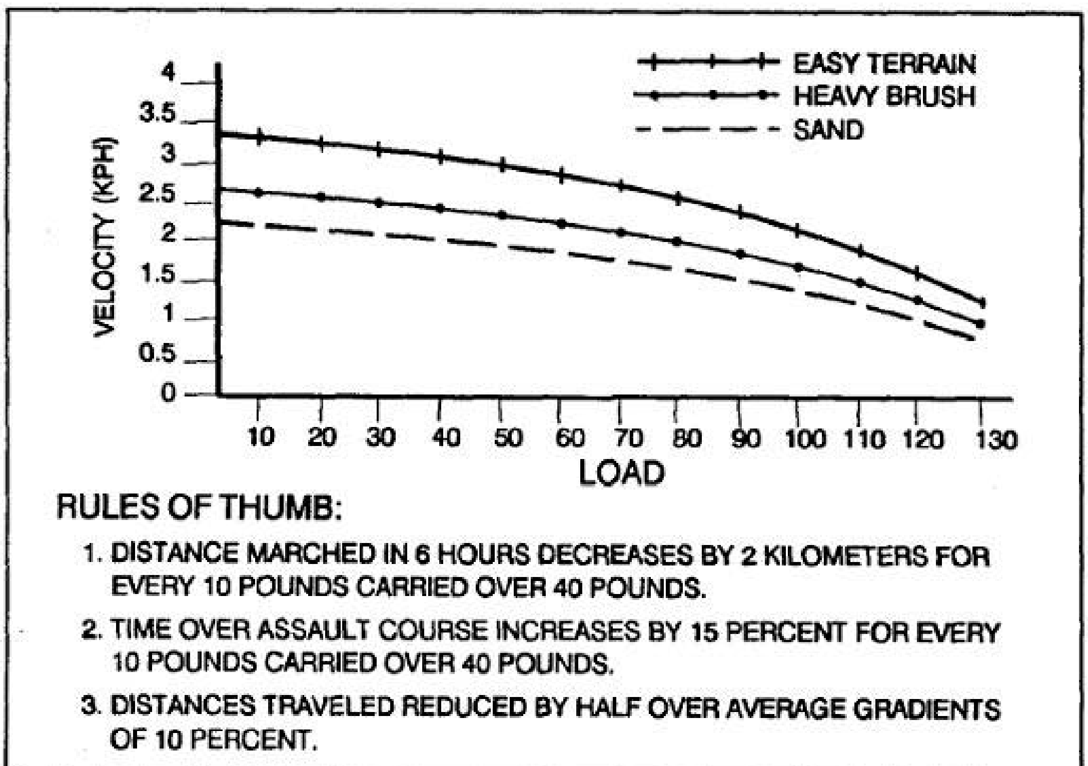

Figure 4. Soldier Load Impacts on March Speed
Source: Headquarters, Department of the Army, Field Manual (FM) 21-18, *Foot Marches* (Washington, DC: Government Printing Office, 1 June 1990), 5-5.

While comparing Soldiers load and combat effectiveness, it also became apparent that there was a psychological dimension to the Soldier load issue which had to be taken into consideration. The linkage between Soldier's load and overall combat effectiveness was described within the studies of S.L.A. Marshall. Marshall noted that tired Soldiers are more susceptible to fear. Once fear sets in, their physical strength drains more rapidly, creating an exponential degradation in the Soldier's overall effectiveness (Marshall 1950, 46-47). Therefore, overburdening Soldiers initiates a cycle of fatigue. The gains of reducing Soldier load should not be measured in pounds; rather gains should be measured in degrees of individual and unit combat effectiveness. This is important to note because it expands the effects of the Soldier's load beyond degraded mobility and into overall effectiveness. If the ramifications of overloading a Soldier were merely physical, they could be partially mitigated by increased duration and frequency of rest periods or through adjustments to movement time tables. However, physical exhaustion and subsequent fears reduce the Soldier's ability to conduct defensive operations as well, degrading the unit's combat ineffective. Therefore, the DOTMLPF solutions to the Soldier's load problem are limited to solutions which directly reduce the load as opposed to mitigating the effects of the load.

Based on the narrative data listed above, it is clear that the current approach march load weight carried by the average infantryman in an IBCT does degrade combat effectiveness. Beyond answering this project's first secondary research question, the findings listed above made it apparent that any research project on Soldier's load had to go beyond a math equation of less weight equals greater mobility. It led to the acknowledgement that weight removed from the Soldier's backs would result in psychological as well as physical improvements to overall combat effectiveness. Once the answer to that research question was determined, the analysis of the data obtained during the review of literature turned to answering the next of the four secondary research questions.

The second purpose of the analysis of the data obtained from the review of literature was to determine what capabilities needed to be designed into the MULE-T in order for it to be deemed a viable material solution for Soldier's load capability gap in the IBCT. A majority of the findings related to this secondary research question were derived from current doctrine on light infantry formations. The remainder of this section highlights those capabilities and their relationship to the evaluation criteria discussed in the previous chapter.

The data obtained highlighted that the IBCT's optimal performance is achieved during fast paced offensive operations in restrictive and severely restrictive terrain (Headquarters, Department of the Army 2006a, A-6). To support the IBCT, the MULE-T must be able to integrate into small unit operations without imposing logistics burdens which are beyond the scope of the unit's support assets. For example, the IBCT has only limited transportation assets. Those assets are dedicated to distribution of supplies and maintaining the capability to transport four rifle companies (Headquarters, Department of the Army 2006a, A-5). Therefore, if the MULE-T required transportation the IBCT could not support employment of the system without degrading its other capabilities. Another logistics consideration is the power source of the vehicle. Although the MULE-T does increase the fuel consumption of a rifle company, it uses the same fuel as the other vehicles assigned to the company.

In order to win on the battlefield, infantry units must maximize the core components of close combat: firepower, mobility, and protection (Headquarters, Department of the Army 2007, 1-6). To sustain the interdependence of the core component of close combat and success on the battlefield, they became the foundation for the development of the evaluation criteria used in this research project. Therefore, the evaluation criteria sought to ensure that the MULE-T increased the unit's mobility without degrading its overall level of protection. However, the MULE-T can have only a limited impact on the element of firepower, save enabling the unit to carry additional ammunition. Versatility was chosen as the third evaluation criteria in lieu of firepower. The decision was made to reflect the evolving demands on the infantry rifle platoon. As noted earlier, the rifle platoon must be as capable at executing high intensity combat against a conventional threat in the open desert as it is against an insurgent threat in an urban area (Headquarters, Department of the Army 2006a, A-6). Therefore, versatility was chosen rather than firepower to account for the shift towards full spectrum operations. The need to determine the net gain to each of these core components drove the factors which guided each of the evaluation criteria. The requisite capabilities discovered during the review of literature and discussed in this section guided the establishment of the evaluation criteria and the factors upon which they were based. The specifics of those evaluation criteria and the factors which supported each of them were discussed in chapter 3.

The material presented in this section framed responses to the first two of the four secondary research questions. The response to each of those questions shaped the development of the tactical scenarios used during this research project. The next section provides the results of each of the tactical scenarios.

Scenario Results

The following section summarizes the results of the three tactical scenarios executed during this research project. The section covers first the urban scenario, then reviews the jungle scenario, and concludes with the mountainous scenario. In each of the tactical scenarios, the platoon consisted of three rifle squads, a weapons squad, and a headquarters element. The infantry rifle platoon was augmented with two MULE-Ts for the mission. The MULE-Ts were operated by two trained operators provided by the company headquarters section in support of the operation. These operators were task organized to the platoon headquarters section (Maneuver Battle Lab 2009, 118). The platoon's mission was to conduct an attack to clear insurgent forces operating in a given area. Each of the scenarios began in a company combat outpost and was based on the mission graphics depicted in figure 2. The graphics depicted in that figure where layered upon the three different terrain types.

Urban Tactical Scenario Results

The first scenario executed was the urban scenario. Prior to deployment on their mission, the platoon loaded their equipment on the two MULE-Ts. The total weight of the equipment loaded on each of the MULE-Ts was 1,102 pounds. Of that total payload weight, 802 pounds consisted of individual Soldier equipment and 300 pounds consisted of additional unit equipment.

The platoon's mission was to conduct an attack to clear insurgent forces operating in a given area. The platoon departed the company combat outpost into an urban neighborhood similar to Baghdad. The platoon moved in a platoon column formation with the two MULE-Ts travelling between fourth squad, the weapons squad, and third squad (see figure 5). The platoon executed a halt to review the intelligence update and conduct final preparation for the action on the objective. However, due to the complex nature of the urban terrain the platoon leader opted not to leave the MULE-T's in a hide site. Instead the MULE-Ts, the platoon sergeant, and the MULE-T operators continued to travel with the third and fourth squads. Once the platoon reached the release point, the platoon sergeant, with the assistance of the MULE-T operators, positioned the MULE-Ts in close proximity to the support by fire positions established around the objective to isolate the target building. The Soldiers occupied positions within buildings while the vehicles where left in the street. An element from each of the two positions tasked a Soldier to maintain visual contact with the vehicles to secure the unit equipment. Once the third and fourth squads isolated the objective area, the assault element, first and second squad, simultaneously cleared the objective area. Once the objective was cleared, the platoon consolidated and reorganized. At that point, the spare ammunition and water aboard the MULE-T was used to replace the supplies the Soldiers expended up to that point. After the platoon completed the tasks associated with consolidation and reorganization, they initiated movement back to the combat outpost using a separate route.

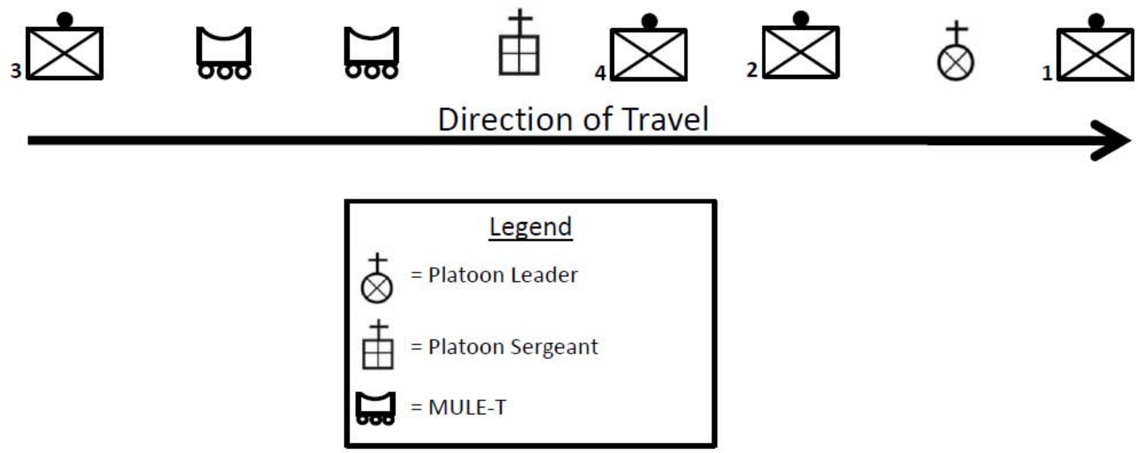

Figure 5. Urban Movement Formation

Source: Created by author with graphics from Headquarters, Department of the Army, Field Manual (FM) 1-02, *Operational Terms and Graphics* (Washington, DC: Government Printing Office, 2004); Headquarters, Department of the Army, Field Manual (FM) 3-21.8, *Infantry Rifle Platoon and Squad* (Washington, DC: Government Printing Office, 2007).

Jungle Tactical Scenario Results

The second scenario executed was the jungle scenario. The platoon's mission was to conduct an attack to clear insurgent forces operating in a given area. Like the urban scenario, the platoon loaded a total of 1,102 pounds on each of the MULE-Ts. Once again, the platoon initiated their movement in a platoon column (see figure 5). However, the MULE-T operators could not deploy the MULE-T through the restrictive terrain of the jungle. The platoon was forced to execute a halt and alter the route of the two MULE-Ts to conform to either open terrain, roads, or trails as available. The platoon leader decided to transition to a modified platoon wedge (see figure 6). Due to the terrain, the MULE-Ts travelled to the left, rear of the formation along terrain better suited to its capabilities and limitations. The left flank squad, third squad, was positioned in close enough proximity to overwatch the MULE-Ts. Short of arriving at the platoon's objective, the platoon leader established an ORP as planned. The platoon leader decided to leave the MULE-Ts in hide sites at the ORP. Third squad remained at the ORP to secure the equipment laden vehicles. The remainder of the platoon divided into assault and support by fire elements. The support by fire element consisted of the weapons squad which established a support by fire position to suppress enemy forces on the objective. The assault element, first and second squads, cleared the objective area of insurgent forces and caches. Once the objective was cleared, the platoon consolidated, reorganized, and initiated movement back to the ORP to link up with their equipment and the security element. The platoon linked up at the ORP and replenished supplies from the MULE-Ts as needed. Once that was complete, the unit executed another tactical movement back to the combat outpost.

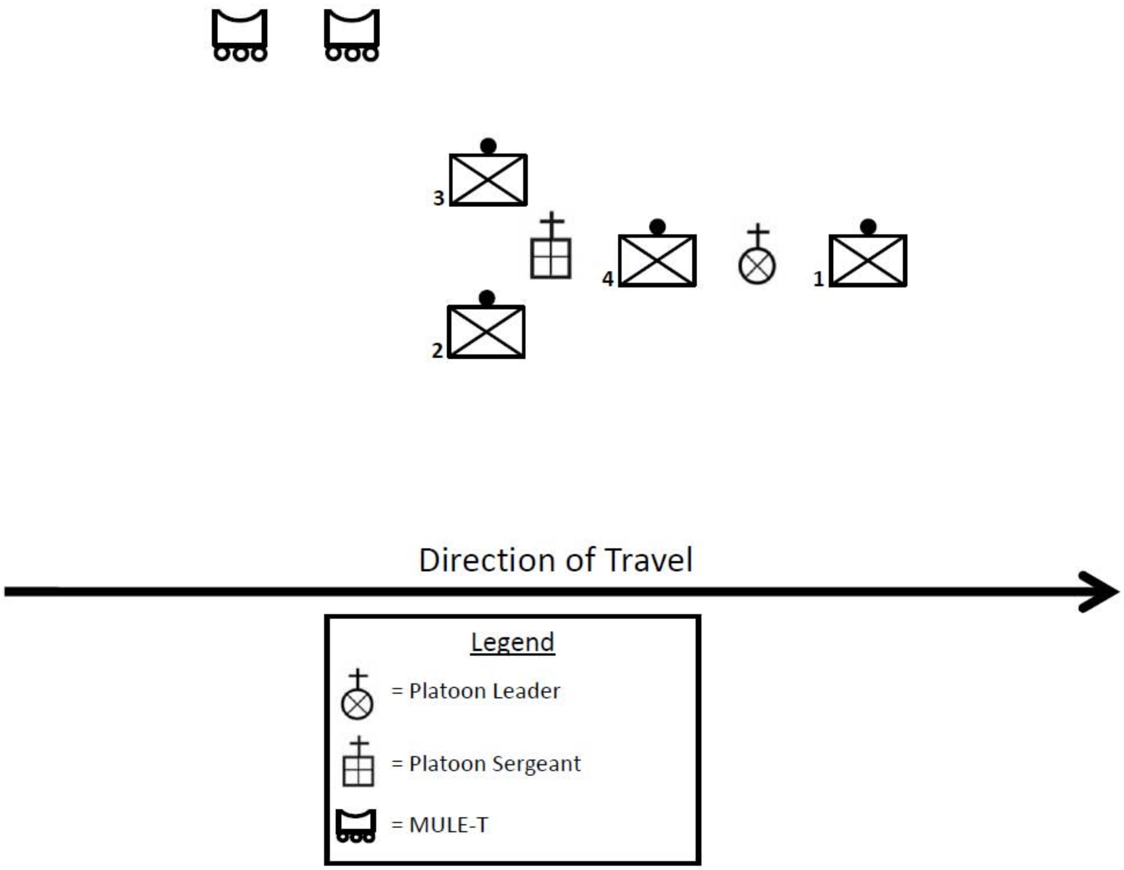

Figure 6. Adjusted Jungle Movement Formation
Source: Created by author with graphics from Headquarters, Department of the Army, Field Manual (FM) 1-02, *Operational Terms and Graphics* (Washington, DC: Government Printing Office, 2004); Headquarters, Department of the Army, Field Manual (FM) 3-21.8, *Infantry Rifle Platoon and Squad* (Washington, DC: Government Printing Office, 2007).

Mountainous Tactical Scenario Results

The final scenario executed was the mountainous tactical scenario. The platoon's mission was to conduct an attack to clear insurgent forces operating in a given area. Like the first two scenarios, the platoon loaded a total of 1,102 pounds on each of the MULE-Ts. Once again, the platoon initiated their movement in a platoon column (see figure 5). The platoon traversed along the side slope of the mountainous terrain en route to their objective. When the MULE-Ts were unable to traverse the same terrain as the Soldiers, the operators repositioned the systems further down the slope of the hill to find a more hospitable side slope. Although the vehicles were unable to maintain the integrity of the formation, the platoon leader did not adjust the formation of the dismounted squads. The operators, who remained collocated with the platoon sergeant, continued to adjust the MULE-T routes, bringing them closer to the formation when the terrain warranted. Due to the extended line of sight around the objective area, the platoon leader decided to establish the ORP earlier than planned. Once again, the platoon leader placed the MULE-T's in hide sites at the ORP and tasked third squad to remain as an ORP security element. Like the jungle tactical terrain, the platoon suppressed the objective with fourth squad while first and second squads assaulted and cleared the objective. Once the objective was cleared, the platoon consolidated, reorganized, and initiated movement back to the ORP to link up with their equipment and the security element. The platoon linked up at the ORP and replenished supplies from the MULE-T's. Once that was complete, the unit executed another tactical movement back to the combat outpost.

The results annotated in the three preceding subsections, generated the second primary source of narrative data for this research project. That data was maintained in three data streams separated according to the tactical scenarios. The next section summarizes the strengths and weaknesses found within those data streams.

Strengths and Weaknesses

This section provides the analysis of the data generated during the conduct of the literature review and the three tactical scenarios. The analysis presented reflects the tactical scenario results versus the three evaluation criteria. The analysis is organized by strengths and weaknesses according to evaluation criterion and scenario.

Mobility Strengths and Weaknesses

This section depicts the mobility strengths and weaknesses of the MULE-T equipped platoon. The mobility evaluation criterion was defined as the platoon's ability to move from place to place without additional delays due to terrain or obstacles, while retaining the unit's ability to accomplish its mission (Headquarters, Department of the Army 2004, 1-127). The strengths and weaknesses listed in this section were guided by the supporting factors listed in table 2. The strengths and weaknesses are summarized at the in table 5.

Mobility Strengths

Several of the strengths presented during this research project were redundant to each of the terrain based scenarios. Those strengths and weaknesses will be discussed first beginning with payload. The purpose of the MULE-T is to carry equipment which would have otherwise been carried by the dismounted infantryman. The payload goal was set at 800 pounds in order to reduce the overall load weight of each Soldier by approximately 45 pounds. In each of the three tactical scenarios, the MULE-T met and exceeded the established standard. The MULE-T was capable of carrying 1,900 pounds of equipment which would have otherwise been carried on the backs of the members of the unit (Pengelley and Williams 2010, 60).

In addition to the weight reduction which came via the payload, the MULE-T has a built in battery charger (Unit of Action Maneuver Battle Lab 2006, E-2-B-4). Batteries have been a major contributor to the increase in Soldier load weights. Soldier equipment, such as radios and optics, has increased the power requirements of the individual and therefore increased the weight he must carry. As seen in figure 7, a sample small unit leader in Afghanistan carries 16 pounds of batteries for a three day mission (Barbero 2009, 66). Approximately 14 of those pounds are not included in the 133 pounds previously shown in figure 3.

Figure 7. Operation Enduring Freedom Battery Weights
Source: Michael D.Barbero, Major General, *Maneuver Center of Excellence Industry Day* (Briefing, Columbus Iron Works and Convention Center, Columbus, GA, 5 May 2009), 66.

From a weight reduction perspective, having the capacity to recharge batteries resident on the MULE-T reduced some of the weights listed in figure 7 by anywhere from one half to two thirds. With a battery charger, the Soldier reduced the number of batteries he carried for each radio from eight each to three each based on the assumption that one battery was charging or waiting to be charged, one was in the radio, and one was fully charged as the next replacement. That means the Soldier carried ten less batteries and reduced the overall load by eight pounds. Since the two team leaders carried one radio each, this equated to a 16 pound weight savings per squad. In an environment where progress is weighed in ounces, eight pounds out of a 133 pound load is a sizeable decrease.

Closely related to the issue of the battery charger was the requirement for communications relay. The MULE-T provides this capability through the four channel Joint Tactical Radio System Ground Mobile Radio (Department of Defense 2009, 127). Although communications equipment carried by the dismounted leaders has drastically been reduced over the past few years, the range and weight of these radios still pose challenges to the light infantry formation. The presence of the four channel ground mobile radio eliminated the need to carry some of the communications equipment otherwise classified as unit or platoon equipment.

The equipment loaded on the payload deck of the MULE-T combined with the battery charger and communications relay weight savings accounted for the cumulative weight savings provided by the MULE-T. As shown in figure 4, those weight savings would translate directly into faster rates of march. A portion of the mobility criterion analyzed the rate at which the MULE-T was able to traverse complex terrain. The small unit formation traverses terrain at an average rate of 2.4 kph during the day and 1.6 kph during the hours of limited visibility (Headquarters, Department of the Army 2007, D-13). In each type of terrain the overall weight of each Soldier's load was approximately 88 pounds. Given this reduced individual load weight, the formation was able to move at a rate of 2.4 kph in the urban scenario, 1.8 kph in the jungle scenario, and 1.5 kph in the mountain scenario (Headquarters, Department of the Army 1990, 5-5). These adjusted movement rates reflect a 53 percent improvement in the mountains, a 56 percent improvement in the jungles, and a 70 percent improvement in the urban areas (Headquarters, Department of the Army 1990, 5-5). Each of those rates contributed to greater mobility of the platoon formation as a whole. The cross country capabilities of the MULE-T permitted the system to keep pace with each of the aforementioned movement rates (Noe 2008, 27).

Of the three individual tactical scenarios, the MULE-T's mobility was best during the urban scenario. The primary mobility concerns in the urban environment were turning radius and size. The turning radius standard was established at one and a half times the vehicle's length in order to enable the unit to reverse directions as the tactical situation dictates (Unit of Action Maneuver Battle Lab 2006, D-6). The MULE-T was capable of executing a pivot turn by raising its front and rear wheels and pivoting on the two center wheels without exceeding a diameter greater than the length of the vehicle (U.S. Army 2009a, 04:03). In addition to exceeding the standard, the MULE-T's Autonomous Navigation System (ANS) and its sensor subcomponents enabled the MULE-T to drastically exceed the intent of the turning radius standard. As an unmanned system with redundant sensors in the front and rear of the vehicle, the vehicle does not have a true forward and reverse like a manned vehicle. In lieu of executing a pivot turn, the operator can simply reverse direction without any degradation in the control capabilities (U.S. Army 2009a, 02:46).

Although the size of the MULE-T was a concern for the urban tactical scenario, it achieved the standard necessary to travel down streets and alleys. The ability to squat the vehicle down to the size of a pickup truck mitigated concerns about low hanging power lines impacting the vehicle's payload (U.S. Army 2009a, 2:52). The other impact of the vehicle's size on mobility will be discussed in further details later in this section.

During the jungle tactical scenario, the MULE-T faced numerous streams and dry gaps. The fording and gap crossing standards discussed in chapter 3 were established to account for this. The MULE-T was able to cross one and half meter gaps, such as trenches, without complications (Military Periscope). When faced with larger gaps with standing or running water, such as streams or creek beds, the MULE-T was able to ford water one and a quarter meters deep (Military Periscope).

As was the case with the jungle tactical scenario, the ability to cross gaps was critical to the MULE-T's performance in the mountainous tactical scenario. During the mountainous scenario, the fording and gap crossing capabilities were exercised, but the MULE-T's performance did not change from what was indicated in the previous paragraphs. Additionally, the ability to negotiate one and half meter steps allowed MULE-T to handle obstacles such as rocks, berms, irrigation ditches, and generally sharp yet short changes in elevation (Military Periscope).

The system's ability to negotiate slopes was a critical subcomponent of the mobility evaluation criterion to a much greater extent during the mountainous scenario than the jungle and urban scenarios. During the mountainous tactical scenario, the unit was frequently required to traverse along the side of the mountain ranges. Although the MULE-T's ability to negotiate a 60 percent forward slope was valuable, the capability to safely traverse a 40 percent side slope exceeded the standard and allowed for a wider range route options for the rifle platoon leader (Military Periscope). Additionally, the MULE-T's independent articulated suspension system stabilized the load as it traversed complex mountainous terrain without compromising the system's mobility (Military Periscope).

Mobility Weaknesses

The primary mobility weaknesses of the MULE were most prominent during the jungle tactical scenario. The MULE-T is 171.4 inches long, 77.5 inches high, and 88.3 inches wide (Department of Defense 2009, 127). These dimensions prevented the MULE-T from moving through the dense vegetation which characterizes jungle environments. The obstacle avoidance capability of the ANS frequently pushed the MULE-T towards trails, roads, or open terrain upon the perception of dense vegetation (Maneuver Battle Lab 2009, 120). Although the operator was able to switch to teleoperational mode to mitigate the aforementioned issue, not all vegetation could be driven through. The physical size of the system simply prevented it from moving through jungle terrain when trees or thick brush were closer than 88.3 inches.

The strengths and weaknesses of the MULE-T and its impact upon the mobility of the rifle platoon were depicted during this section (see table 5). Although many of the strengths and weaknesses were applicable across each of the terrain types, they were more pertinent to some as opposed to the others. The following section provides the strengths and weaknesses observed under the protection criterion.

Table 5. Mobility Strengths and Weaknesses

Definition: The platoon's ability to move from place to place without additional delays due to terrain or obstacles, while retaining the unit's ability to accomplish its mission

Scenario	Strengths	Weaknesses
Urban	• Turning Radius • Speed • Articulated suspension • On board battery charger • Communications relay capability • Payload • Rate of march	• Physical size
Jungle	• Fording ability • Gap crossing capability • Speed • Slope • On board battery charger • Communications relay capability • Payload • Rate of march	• Physical size
Mountain	• Fording ability • Gap crossing capability • Speed • Slope • Step negotiation • Articulated suspension • On board battery charger • Communications relay capability • Payload • Rate of march	• Physical size

Source: Created by author.

Protection Strengths and Weaknesses

This section depicts the protection strengths and weaknesses of a MULE-T equipped platoon. The protection evaluation criterion was defined as the impact of the MULE-T on the unit's ability to preserve the force so the platoon leader could apply maximum combat power (Headquarters, Department of the Army 2008, 4-6). Many of the weaknesses discussed during this section are a counterweight of the mobility benefits listed in the preceding section. Like the mobility section, many of the strengths and weaknesses were common across all of the tactical scenarios.

Protection Strengths

The first common strength presented under the protection criterion was payload. Many of the factors discussed, like payload, were also applicable across multiple evaluation criteria. The distinguishing feature between such factors was how it impacted the unit. As such, the background data on these factors will not be readdressed for the sake of repetition, instead only the unique impacts are listed the second time a factor is mentioned. For example, this section will not readdress the math behind the weight savings afforded by the MULE-T's payload; it will only focus on how those weight savings affected unit protection.

Overburdening Soldiers with heavy loads slows them, drains their physical strength, and degrades functionality. When the load carried exceeds 45 percent of the Soldier's weight, functional abilities begin to degrade at a more rapid rate and chances of becoming a casualty increase (Headquarters, Department of the Army 2006b, 11-4). Earlier in this document, S.L.A. Marshall's cycle of fatigue was mentioned. Marshall noted that tired Soldiers are also more susceptible to fear. Once fear sets in, physical strength drains more rapidly, creating an exponential degradation in the Soldier's overall effectiveness (Marshall 1950, 46-47). The reduced weight of the Soldier's load not only made the Soldier more mobile, it also improved the unit's protection level by improving individual Soldier psyche and ability to provide security to the formation. The MULE-T's capability to reduce the Soldier's load allowed dismounted Soldiers to maintain the stealth and security necessary to evade unwanted enemy contact without relying on resupply operations (Headquarters, Department of the Army 2006b, 4-41).

The next strength exhibited as part of the protection evaluation criteria was an all weather capability. The IBCT is expected to operate in all types of weather and during any time of the day (Headquarters, Department of the Army 2006b, 1-1). The various components of the ANS and the mobility characteristics of the MULE-T allowed the system to function during day and night operations and during all the same types of weather which the dismounted platoon was expected to operate (Noe 2008, 49-52). The ability to choose when the platoon will fight allows the platoon to continue to leverage the protection afforded by limited visibility or inclement weather.

The next protection strength observed was the operator control of the platform. The MULE-T is controlled through a man packable, wireless controller known as the Common Controller (U.S. Army 2009b, 0:33). The MULE-T was capable of being controlled in the teleoperational or semi-autonomous control mode (Military Periscope). The teleoperational mode allowed the Soldier operating the system to provide detailed control commands through the dismounted control device (National Institute of Standards and Technology 2004, 14). The system was also capable of operating in the semi-autonomous mode. This mode allowed the operator to decrease the level of human to robot interaction by assigning general tasks or waypoints (National Institute of Standards and Technology 2004, 14). The vehicle then relied on the ANS sensors and computing system to determine the optimal way to execute each of the assigned tasks. For example, when crossing a gap, the system, not the operator, determined how to articulate each of the road wheels to cross the obstacle.

In addition to the semi-autonomous mode, the MULE-T also possesses a leader-follower capability. This capability allows the MULE-T to follow the route previously travelled by the controller (National Institute of Standards and Technology 2004, 17). As the control device records its location, it creates a series of waypoints which are then translated into a route by the ANS computer. The MULE-T can then follow that route while maintaining a predetermined separation distance. Like the semi-autonomous control mode, this further decreased the amount of time and attention the operator dedicated to controlling the vehicle and allowed the operator to scan the assigned sector and provide security.

The other factor of operator control which impacted protection was the control range. The MULE-T exceeded the control range standard, two kilometers, in each of the three scenarios (Noe 2008, 27). The maximum control range achieved varied based on line of sight differentials. In each scenario, communications links between the operators and the system were impeded by obstacles such as dense vegetation, varying levels elevation, and buildings. Given the close proximity of the small unit in the urban terrain, the control ranges were short. When the signal was lost, the operator simply positioned the antennae closer to a window. Control ranges in the mountainous scenario were only interrupted when the operator and the MULE-T were on opposite sides of the crest of a hill. Although the system did not fail to meet the specified standard, the dense vegetation of the jungle scenario had the greatest impact on control ranges. In each of the scenarios the extended control range allowed the distance the vehicle from himself and the unit to offset some of the weaknesses which are discussed later in this section. Although this range does not improve the overall protection when compared to a platoon without MULE-Ts, it did serve as a mitigating factor.

A secondary task for the MULE-T is to support casualty evacuation (Unit of Action Maneuver Battle Lab 2006, E-2-B-4). Although the unit has assigned medics who can deploy forward to provide immediate care at the point of injury, these medics are dismounted like the forces they support. Although this is not an exclusively unmanned task, the unit's medics or combat lifesavers could use the MULE-T to transport casualties out of the immediate area of contact without further jeopardizing additional Soldiers or the limited number of ambulances organic to the unit. Its ability to drive in forward or reverse without control degradation is beneficial if the unit needs to evacuate a casualty from a tight location such as the end of an alley. Although this capability can improve the unit's protection, it is limited in its effectiveness. Units would not likely want to transport casualties beyond distances which they can overwatch. Additionally, using the MULE-T for this purpose requires the unit to remove and carry the equipment which was being stored upon it. This would not only put them at risk of enemy fire during the execution of such a transfer, but would also negate the Soldier load relief for subsequent movements until the system is returned and reloaded.

During the worst case scenario when the platoon is forced to evacuate a casualty back to the combat outpost or to another distant location by foot, this capability became a great force protection multiplier. During such an event, the unit can load the casualty onto the vehicle and escort the vehicle. In doing so, the fire team which would have been required to carry just one casualty can now provide security thereby reducing the chances of incurring additional losses. Despite the degree of its effectiveness, or likelihood of employment, it is still an improvement upon the current protection capabilities of the rifle platoon.

Protection Weaknesses

On the other hand, several weaknesses were also manifested when the MULE-T was integrated into the rifle platoon. One of the biggest concerns with adding vehicles, whether manned or unmanned, to a light infantry platoon was the degradation in the element of surprise. The element of surprise is crucial to protecting the force from unwanted enemy contact. To ascertain the impact of the MULE-T on the unit’s ability to achieve surprise and maintain its level of protection, the study assessed the vehicle’s noise emissions and visual profile to ensure that unit is able to maintain security during movement (Headquarters, Department of the Army 2006b, 3-12 to 3-1). The MULE-T is powered by a diesel engine which emits an audible signature which was heard beyond the audible signatures of the dismounted unit moving across the same terrain (Military Periscope). In addition to engine noise, the MULE-T could not control the noises it created moving through or over foliage. Although this was not as much of a concern during the urban scenario, it did degrade the units protection as it traversed the loose rock of the mountainous terrain as well as the dead fall of the jungle environment. Maintaining noise discipline is critical to maintaining security during movement (Headquarters, Department of the Army 2006b, 3-12). Failure to do so degraded the close combat component of protection.

In addition to the audible signatures, the MULE-T also presented a large visual signature which significantly degraded the unit's ability to maintain the element of surprise during tactical movement. With the physical dimensions of 171.4 inches long, 77.5 inches high, and 88.3 inches wide, the MULE-T presents a noticeably larger visual profile than dismounted (Department of Defense 2009, 127). Although the articulating suspension system allows the system to shrink its profile to some extent, it was not a significant enough improvement to its overall size. When combined with its audible signature, the MULE-T failed to meet the established standard deemed necessary to maintain the element of surprise in any of the tactical scenarios.

In order to mitigate the visual and audible signatures of the MULE-T and their impacts on the supported unit, the unit was forced to increase the separation distances between the MULE-T and the main body formation. The unit had to dedicate a portion of its combat power to overwatch the system during movements and halts to ensure that the equipment aboard the MULE-T was secure from capture, destruction, or pilferage. Although this technique may have improved the unit's overall protection level when compared to moving in close proximity to the MULE-T, it degraded their ability to mass firepower and their flexibility to maneuver rifle squads. The net result was a degradation to unit protection in each of the tactical scenarios. Although this was common across all the scenarios, it was most pronounced during the jungle and mountainous tactical scenarios.

The jungle tactical scenario also illuminated three other weaknesses which fell under the protection evaluation criterion. The first weakness, albeit minor, referred back to the security of the equipment payload. The MULE-T's capacity to haul large quantities of cargo improved the protection levels of the Soldiers, but there was an issue pertaining to payload during the jungle scenario. Although the MULE-T is equipped with a cargo tie down system, the low hanging branches and dense vegetation of the jungle terrain were still capable of dislodging and damaging equipment on MULE-T's top deck payload platform.

The second weakness was related to the control of the system. During the jungle tactical scenario, the obstacle avoidance capability of the ANS frequently pushed the MULE-T towards trails, roads, or open terrain upon the perception of dense vegetation (Maneuver Battle Lab 2009, 120). While the teleoperational mode allowed the operator to precisely control the system or override false obstacle avoidance readings, it forced him to focus his attention on the display screen on the control device, thereby preventing him from scanning his sector. As long as this was the case, another Soldier in the unit had to provide security for the MULE-T operator.

The final weakness was spawned from the mobility weakness discussed during the previous section and the jungle tactical scenario results. In the jungle scenario, the MULE-T's mobility forced the system to travel along danger areas such as trails, roads, or open terrain. In doing so, the unit was forced to chose among three options. The first option was to travel along or in close proximity to the same danger areas in order to overwatch the system. The second option was to task one of its subordinate squads to achieve the same effect using less combat power. The final option was to continue upon a route optimal for dismounted movement and risk destruction or capture of the unarmed MULE-T by enemy forces or the indigenous population. In each of the options, the scenario results suggest that the net gain of lightening the Soldier’s load did not outweigh the degradation to the unit’s protection.

The strength and weaknesses of the MULE-T and its impact upon the protection of the rifle platoon were depicted during this section (see table 6). Many of the weaknesses which were depicted in this section were either a direct or indirect result of strengths listed in other areas of this report. For example, the large payload capacity of the MULE-T contributes to its large audible and visible signature. The next section provides the strengths and weaknesses observed under the versatility criterion.

Table 6. Protection Strengths and Weaknesses

Definition: The impact of the MULE-T on the unit’s ability to preserve the force so the platoon leader can apply maximum combat power

Scenario	Strengths	Weaknesses
Urban	• Operator control • Payload • On board battery charger • Communications relay capability • Casualty evacuation • All weather capability	• Visual Signature
Jungle	• Operator control range • Payload • On board battery charger • Communications relay capability • All weather capability	• Visual Signature • Audible signature • Reliance on teleoperational control • Security of equipment payload
Mountain	• Operator control • Payload • On board battery charger • Communications relay capability • Casualty evacuation • All weather capability	• Visual Signature • Audible signature

Source: Created by author.

Versatility Strengths and Weaknesses

This section discusses the strengths and weaknesses of the MULE-T equipped platoon as they pertain to the versatility evaluation criteria. The criterion was defined as the unit's ability to adapt to diverse mission requirements and flexibility to respond to an evolving situation. The intent of the evaluation criterion was to ensure that the IBCT remained the most versatile of the three BCTs (Headquarters, Department of the Army 2006a, A-6). This section, like the last two sections, provides common strengths and then scenario specific strengths. Following the strengths, the section discusses the common weaknesses as well as the scenario specific weaknesses.

Versatility Strengths

The first strength examined under the versatility evaluation criterion was range. Range analyzed the distance the MULE-T could carry the payload described during the previous sections using only the fuel within its tanks. The MULE-T exceeded the range standard in each of the three types of terrain. In each data stream, the MULE-T was capable of travelling approximately 200 kilometers (Department of Defense 2009, 127). The surplus range capability allowed the unit to triple the duration the MULE-T could operate without requiring fuel resupply.

As previously discussed during the mobility strengths and weaknesses, the MULE-T exceeded the speed standard during each of the tactical scenarios. The speed of the MULE-T provided additional flexibility and employment options to the supported unit. To mitigate some of the challenges identified under the mobility and protection evaluation criteria, the MULE-T was offset from the unit or placed in a hide site at locations such as the ORP when the security situation allowed. In those instances, the speed of the MULE-T allowed it to close the distance gap at a rate approximately three times faster than the dismounted Soldier. When the terrain permitted, the speed of the system also permitted the mission leader to transfer additional Soldier and unit equipment to the MULE-T when he believed the MULE-T's response times supported its anticipated demand.

Although the speed standards examined the MULE-T's cross country speed, it was also determined that the MULE-T's road speed is approximately 65 kph (Pengelley and Williams 2010, 60). Although the road speed creates reliability, size, and autonomy challenges, it also further enhanced the unit's versatility by generating additional employment options. When you consider its range and road speed capabilities, the MULE-Ts can be self deployed with a convoy as opposed to requiring transportation support. Although this would increase fuel consumption rates for individual movements, it would alleviate the need to increase the number of turns required to transport the unit and preclude the need to assign additional transportation assets to the IBCT to support its integration.

As previously mentioned, the purpose of the MULE-T is to offload weight from the Soldier's back to make him more mobile. By offloading equipment to the MULE-T, the unit, now lighter and faster, increased the likelihood of mission success. The MULE-T also increased the unit's endurance, thereby, allowing for faster saturation of the area of operations (Headquarters, Department of the Army 2006b, K-9).

The cumulative effects of range and payload enabled the unit to conduct operations out to greater distances or with greater frequency. The extended range afforded by the MULE-T is also supported by the battery charging and communications relay capabilities. These capabilities increased the versatility of the unit without degrading protection. The on board battery charger prevents the unit from having to carry more batteries to account for the longer duration of the mission. The improved communications ranges afforded by the vehicle borne radio systems allows the unit to maintain the lines of communication back to their higher headquarters with greater reliability. That, in turn, empowers the platoon leader to seek additional enablers, such as close air support through the company headquarters. Enablers may not have previously been available without the construction of range extended antennas.

Like S.L.A. Marshall, Captain Aaron Childers and Sergeant First Class David Banks experienced the psychological effects of a decreased Soldier's load during their deployment to the Ghazni Province in Afghanistan during 2007. However, in their case, the psychological effects were also experienced by the local populace they were tasked to protect. By decreasing the Soldier's load, their unit was able to increase the frequency and duration of dismounted operations while deployed to Afghanistan. Both note that when the unit increased the frequency of dismounted patrols, the Afghan population treated them with greater hospitality. When questioned, the Afghans attributed the shift in atmospherics to the fact that unlike previous coalition or Soviet units, the unit reduced the barrier between the two groups by dismounting their vehicles (Childers and Banks 2009, 37). Therefore, the MULE-T's ability to reduce the Soldier load weight of the unit improves the unit's ability to execute missions across the full spectrum of operations.

The strengths of the MULE-T's impact upon the protection of the rifle platoon were depicted during this section (see table 7). There were no weaknesses observed during the tactical integration of the MULE-T to the infantry rifle platoon in relation to the versatility evaluation criterion. That is not to say that the MULE-T will only make the unit more versatile. Rather it suggests that issues that may degrade the IBCT's versatility were beyond the scope of this study and the tactical level evaluation criteria. The next major section will provide the research project findings.

Table 7. Versatility Strengths and Weaknesses

Definition: The unit's ability to adapt to diverse mission requirements and its flexibility to respond to the evolving situation during those missions

Scenario	Strengths	Weaknesses
Urban	• Speed across complex terrain • Road speed • Operator control range • Range • On board battery charger • Communications relay capability	
Jungle	• Speed across complex terrain • Road speed • Operator control range • Range • On board battery charger • Communications relay capability	
Mountain	• Speed across complex terrain • Road speed • Operator control range • Range • On board battery charger • Communications relay capability	

Source: Created by author.

Findings

This section provides the findings of the research project. The findings were based on the cumulative effects of the strengths and weaknesses observed during the tactical scenarios. The findings provide discussions of whether the MULE-T exceeded, met, or failed to meet the evaluation criteria during each of the tactical scenarios. The results are depicted in table 8 using a red, amber, green rating system. A green assessment indicated that the MULE-T exceeded the evaluation criteria. An amber assessment meant that the MULE-T met the evaluation criteria. Finally, a red assessment meant that the vehicle failed to meet the evaluation criteria.

Mobility Findings

The results of the mobility evaluation criterion were mixed among the three tactical scenarios. In each of the tactical scenarios the reduced Soldier's load weight allowed Soldiers and therefore the unit to vastly improve dismounted mobility. In each case the independently articulated suspension system allowed the MULE-T to conquer mobility challenges such as fording water, crossing gaps, and negotiating steps. However, the ability, or inability, to handle additional obstacles determined if the MULE-T could keep pace with the dismounted platoon and achieve the mobility evaluation criterion standards.

Finding

The MULE-T exceeded the mobility evaluation criteria during the urban tactical scenario.

Discussion

The 70 percent increase in the individual Soldier's rate of march was a clear indicator of the ability of the MULE-T to improve Soldier mobility within an urban area. The system's turning radius, or its ability not to require a turning radius, allowed the

MULE-T to overcome its size challenges and keep pace with the lighter, more mobile dismounted infantry for the duration of the scenario.

Findings

The MULE-T failed to achieve the standards established for the mobility evaluation criteria during the jungle tactical scenario.

Discussion

The size of the vehicle was simply too large to be mobile in a jungle environment. The height and width of the system did not permit it to move through the close confines of the densely vegetated terrain. Despite the fact that the MULE-T allowed the Soldiers to move 56 percent faster than they were formerly capable of moving (Headquarters, Department of the Army 1990, 5-5), the 88 inch wide, 77.5 inch high MULE-T's lack of jungle mobility negated that improved rate of march gains.

Finding

The MULE-T achieved the standards established for the mobility evaluation criteria during the mountainous tactical scenario.

Discussion

Although the MULE-T did not exceed the mobility criterion standards as it did during the urban scenario, it did fare better during the mountainous scenario than it did during the jungle scenario. The rate of march gains during the mountainous scenario represented the smallest percentage increase of the three terrains, yet it was still more than a 53 percent increase over a unit not equipped with a MULE-T (Headquarters, Department of the Army1990, 5-5). Despite the fact that the size of the vehicle posed challenges during the mountainous tactical scenario, the MULE-T's ability to negotiate front and side slopes allowed it to overcome those obstacles.

Protection Findings

Like mobility, the results of the protection evaluation criterion were mixed among the three tactical scenarios; however, they were not as disparate as the mobility findings. Just as the MULE-T's payload improved individual mobility across the scenarios, it also improved the individual's psyche and heightened his ability to provide security throughout each of the tactical scenarios (Marshal 1950, 46-47). The ability to operate during the hours of limited visibility and through all weather conditions sustained unit protection. Although the operator control range and levels of autonomy built into that control surpassed the standard, in most cases it was not enough to mitigate the protection weaknesses incurred by the integration of the MULE-T. Those weaknesses are discussed next.

Finding

The MULE-T failed to achieve the standards established for the protection evaluation criteria during the jungle tactical scenario or the mountainous tactical scenario.

Discussion

The visual and audible signature of the MULE-T negated the light infantry's element of surprise in both the jungles and mountains. Although doctrine highlights that "total surprise is rarely essential or attainable," the level of surprise attainable must be commensurate with the type of supported organization (Headquarters, Department of the Army 2006b, 4-2). Mechanized infantry formations compensate for the higher audible and visual signature emissions with speed and firepower. The light infantry forces of the IBCT rely on their ability to stealthily move across terrain. Unfortunately, the increased speed which resulted from the weight reductions afforded by the MULE-T cannot mitigate the signatures it emitted.

Without the element of surprise, the unit was constantly forced to face a prepared enemy or the unit could not prevent the enemy from evading capture. During the jungle scenario, the lack of mobility also forced the unit to travel in close proximity to danger areas thereby further decreasing their protection. In each scenario, these factors jeopardized the unit's ability to preserve the force and therefore failed to achieve the protection evaluation criterion.

Finding

Conversely, the MULE-T met the protection evaluation criteria during the urban tactical scenario.

Discussion

Although the MULE-T's size and audible signatures did not improve in the urban scenario they were more acceptable than during the other two tactical scenarios. One of the most significant differences between urban and other types of terrain is the intimate interaction between Soldiers and the civilian populace (Headquarters, Department of the Army 2006b, 12-8). The heavy presence of civilians in the urban area also decreases the chances of evading the enemy's reconnaissance network whether travelling with or without the MULE-T's. Additionally, the high levels of noise and reduced visibility of the urban areas minimize the overall impact on the unit's ability to achieve the element of surprise (Headquarters, Department of the Army 2006b, 12-8). When balanced against the protection gains from the weight reduction, the security afforded by the reduced load was enough to allow the unit to maintain its level of protection and achieve the evaluation criteria standards (Headquarters, Department of the Army 2006b, 12-8).

In summary, the protection evaluation criterion became a balancing act between increased security from reduced Soldier load weight and the loss of the element of surprise. During the mountainous and jungle tactical scenarios the protection weaknesses outweighed the benefits of the reduced Soldier's load. However, the environmental characteristics of the urban scenario negated the weaknesses enough for the MULE-T equipped platoon to attain the minimum evaluation criteria standards. The versatility evaluation criterion is examined in the next subsection.

Versatility Findings

Unlike the previous two evaluation criterion, the results of the versatility evaluation criterion findings were consistent across the three tactical scenarios.

Finding

The MULE-T exceeded the standards established for the versatility evaluation criteria for each of the three terrain based tactical scenarios.

Discussion

Factors such as MULE-T's range, its cross country speed, the reduced load of the dismounted Soldier, and improved lines of communications all contributed to increases in unit versatility. The lighter, more mobile, platoon increased its versatility by simultaneously improving its ability to kill or capture enemy forces while improving its ability to connect with and protect the population. The net gain was a versatile unit more capable of conducting full spectrum operations.

Summary of the Findings

As previously discussed within this section, the MULE-T's performance varied across the three tactical scenarios (see table 8). During the urban tactical scenario, the MULE-T exceeded the standards for the mobility and versatility evaluation criteria and met the standards for the protection evaluation criterion. During the jungle tactical scenario, the MULE-T failed to achieve the standard for the either the mobility or the protection evaluation criteria, but exceeded the versatility evaluation criterion standards. On the other hand, the MULE-T exceeded the versatility criterion, met the mobility criterion, and failed to achieve the protection criterion during the mountainous tactical scenario.

Table 8. Consolidated Assessment Table

Evaluation Criteria Title	Urban Scenario	Jungle Scenario	Mountain Scenario
Mobility	Green	Red	Amber
Protection	Amber	Red	Red
Versatility	Green	Green	Green

Source: Created by author.

Summary

This chapter provided the findings of the qualitative research study detailed in the chapter 3. The Soldier's load status provided the details of the current weight carried by the average infantryman deployed to Iraq and Afghanistan. This chapter also addressed the impacts of the Soldier's load upon combat effectiveness. Next the chapter described the capabilities which the MULE-T required in order to successfully integrate into an IBCT rifle platoon. Those capabilities were then analyzed according to the evaluation criteria. The findings of each of the criteria were discussed based on the data generated during the execution of the three tactical scenarios. The results of the finding are depicted in table 8. The findings and analysis detailed in this chapter set conditions for developing a response to the research questions. The response to each question, conclusions from the study, and recommendations are provided in the next and final chapter.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this research project was to determine if the MULE-T is a viable mitigation strategy for the Soldier's load problem in the IBCT. The purpose of this chapter is to provide the conclusions and recommendations based on the findings presented in the previous chapter. There are three major sections within this chapter. The first section, conclusions, provides responses as well as supporting rationale to the project's secondary and primary research questions. The second section, recommendations for action, details changes which should be made to optimize the MULE-T for the IBCT. The third section, recommendation for further study details issues which arose which warrant further attention but were beyond the scope of this research project.

Conclusion

This section provides the conclusions of the research project based on the findings provided in chapter 4. The first secondary research question asked if the approach march load weight carried by the average infantryman in an IBCT degraded combat effectiveness. The review of literature suggests that the current Soldier's load does degrade combat effectiveness. The current Soldier's load weighs approximately 133 pounds (Barbero 2009, 63). When carrying a load that heavy, a Soldier's mobility and marksmanship abilities are degraded (U.S. House of Representatives 2009, 3).

Additionally, the current Soldier's load weight degrades the Soldier's psychological well being and degrades the Soldier's defensive capabilities (Marshall 1950, 46-50).

The next secondary research question asked what capabilities the MULE-T needed to possess to be a viable material solution to the Soldier load challenge in the IBCT. The research project concluded that the MULE-T must improve the mobility of the infantry rifle platoon and increased its versatility without degrading its protection to an unacceptable level. Mobility and protection were chosen because they are two of the three core components of close combat which must be maximized for the rifle platoon to be successful on the battlefield (Headquarters, Department of the Army 2007, 1-6). Versatility was chosen because it is the characteristic which distinguishes the IBCT from other BCTs. It also allows the rifle platoon to be equally adept across the range of operations, in all types of terrains, and against all types of enemy forces (Headquarters Department of the Army 2006a, A-6).

The third secondary research question asked if the capabilities and specifications of the MULE-T met the needs of the IBCT. As depicted in table 8, the MULE-T's performance varied across the three tactical scenarios. The MULE-T performed best during the execution of the urban tactical scenario when it exceeded or met each of the evaluation criteria. During the jungle tactical scenario, the MULE-T failed to achieve the standard for the either the mobility or the protection evaluation criteria. On the other hand, the MULE-T exceeded the versatility criterion, met the mobility criterion, and failed to achieve the protection criterion during the mountainous tactical scenario.

The primary research question asked if the MULE-T is a viable mitigation strategy for the Soldier's load problem in the IBCT. Although the MULE-T performed better in some types of terrain than others, the IBCT cannot always choose the terrain in which it will fight. Therefore, based on the findings and analysis presented in chapter 4, the MULE-T should not be integrated into the IBCT modified table of organization and equipment. The emergent theme throughout the findings is that the size of the MULE-T is problematic for this type of formation. In each of the three instances where the system failed to attain the standards established for the evaluation criteria, the root cause of the failure was size.

Given the determination that the MULE-T is not a viable mitigation strategy for the Soldier's load problem in the IBCT, the final phase of the research project was to answer the fourth secondary research question. The fourth and final secondary research question as what changes should be made to the MULE-T's requirements to optimize the system for the IBCT. The answer to that question is presented in the subsequent section.

Recommendations for Action

As previously identified, the major deficiency preventing the MULE-T from being successfully integrated into the IBCT was its size. To address that issue, this section provides recommendations for requirements changes intended to optimize the MULE-T for the IBCT. These changes should either be incorporated into future revisions of the soon to be published Initial Capabilities Document for Unmanned Systems or subsequent capability development and production documents (Censer 2010). The findings for each of the evaluation criteria identified areas where the capabilities of the MULE-T far exceeded the needs of a dismounted small unit. For each instance where a capability exceeded the needs of the formation, a size, weight, or power penalty was incurred by the MULE-T. To reduce the overall size of the vehicle, the payload, range, and speed requirements for the MULE-T should be reduced.

The first recommendation is to reduce the payload requirement for the MULE-T to 950 pounds. During each of the tactical scenarios the MULE-T exceeded the standard for the payload evaluation criteria. A premise of this study was that the current weight of the Soldier's load has degraded the tactical mobility of the IBCT. Therefore, it would stand to reason that the higher the payload capacity of the MULE-T, the more effective it is in mitigating the Soldier load problem. The 1,900 pound payload of the MULE-T could reduce the overall load of each of the 18 Soldiers in the two rifle squads it is designed to support by approximately 105 pounds each. However, the standard for this project was set at 800 pounds because there are simply items within the Soldier's load which cannot be offloaded to the MULE-T for tactical reasons. Items such as individual body armor, the basic load of ammunition, and water must be carried at all times or retained within arm's length of the Soldier. In doing so, these items are at his disposal if the Soldier comes under fire. Relying on the MULE-T to drive from Soldier to Soldier while in contact with the enemy would reduce the Soldier's survivability and effectiveness and likely result in the destruction of the system shortly after contact began. Although, exceeding the payload standard by 1,100 pounds allows the MULE-T to carry additional items, such as additional food, water, tools, or ammunition, which may make the unit more effective, it comes at a price. In order to propel that higher payload capacity, it requires a larger engine which results in a larger UGV.

Therefore, the payload requirement for the MULE-T should be reduced to 950 pounds. The reduction will cut the UGV's current payload capability in half. Despite the reduction, the MULE-T would still reduce the load of each Soldier by approximately 45 pounds. It would also allocate another 140 pounds of its payload capacity to unit equipment.

The second recommended change involves the range of the system. Like payload, the MULE-T exceeded the evaluation criterion standards for range in each of the various terrains. By exceeding the standard, it offered the unit some additional flexibility in its employment. As discussed in the previous chapter, the range of the MULE-T reduced the frequency of refueling operations required to support the system. However, the extended range is another contributing factor towards the size of the vehicle. The increased range capability requires a larger fuel tank which not only increases the design space, but also increases the weight. A larger fuel tank with more fuel increases the weight of the vehicle and contributes to the need for a more powerful engine.

Hence, the range requirements of the MULE-T should be reduced to 100 kilometers. As was the case with payload, this will degrade the MULE-T's current capabilities by one half. A 100 kilometer range is still slightly more than three times longer than the distance which a dismounted squad is expected to travel within the span of a day (Unit of Action Maneuver Battle Lab 2006, E-2-B-3). Although this will result in a higher frequency of required refueling operations, it achieves its stated purpose of supporting the dismounted squad beyond the duration of a given mission.

Finally, the speed requirements of the MULE-T should be reduced. The cross country speed requirement should not be adjusted to ensure that the system retains its flexibility and responsiveness. However, the road speed requirements should be deleted from the requirements documents. Although this reduction, combined with the range reduction, will negate the capability to self deploy the MULE-T with convoys, it is a necessary reduction to optimize the platform for the IBCT. If the MULE-T is too large to employ alongside the dismounted infantry squad, its ability to self deploy is pointless. Deleting this requirement will reduce the demands on the propulsion system and thereby present a weight savings opportunity. Additionally, it will also improve the UGV's overall reliability and reduce the processing demands on the ANS. By maintaining the speed requirement over complex terrain, the requirements documents would still maintain a viable design benchmark regarding MULE-T speed.

This section highlighted three focus areas where reducing capability could improve the overall effectiveness of the vehicle by reducing its size. The MULE-T dimensions of 171.4 inches long, 77.5 inches high, and 88.3 inches wide proved to make the UGV too large to provide the mobility and protection needed for the infantry rifle platoon to successfully conduct full spectrum operations across all types of terrain (Department of Defense 2009, 127). The changes to the payload, range, and road speed requirements are intended to allow the rifle platoon to reap the load carrying benefits the systems is capable of providing while mitigating the mobility and protection weaknesses observed during this research project. The following section will provide recommendations for further study.

Recommendations for Further Study

This section frames issues relevant to the Soldier's load and the MULE-T which were beyond the scope of this research project. It highlights three recommendations for future study. Those recommendations include a discussion on alternative methods of movement, the option of fielding the MULE-T as theater provided equipment, and the two phases of DOTMLPF assessments which must be conducted.

The first recommendation for further study is to examine alternative forms of movement for load carrying UGVs. The exact impacts of implementing the recommended requirements changes listed in the previous section are unknown. However, it is plausible that the MULE-T will still be too large for the IBCT even if all the recommended requirements changes are implemented. Therefore, it will be necessary for the acquisition community to determine what the ideal platform is for this type of task. Organizations such as Boston Dynamic, sponsored by the Defense Advanced Research Projects Agency, have deviated from the notion that all vehicles must be wheeled or tracked and begun testing a quadruped load carrying UGV known as the Big Dog (Pengelley and Williams 2010, 59). Other organizations have turned to technologies such as the Human Universal Load Carrying System to enhance the Soldier's ability to carry their current load. The Human Universal Load Carrying System is a powered exoskeleton designed to assist the dismounted Soldier with heavy loads (Pengelley and Williams 2010, 61). Each of these systems offers a unique set of capabilities and limitations. If the acquisition community wants a near term solution to the Soldier's load gap in Afghanistan, it needs to clearly identify what capabilities are most important, which limitations are acceptable, and then rapidly transition from experimentation to fielding. Beyond Afghanistan, this question must be addressed to ensure the Army chooses a materiel solution capable of remaining relevant to the future force.

However, in doing such a search it may become apparent that the MULE-T is good enough for Afghanistan. This study focused on the viability of the MULE-T as a program of record for future inclusion universally into IBCT modified table of organization and equipment. As such, the MULE-T could not achieve its desired purpose in one third of the major terrain types in which the IBCT is expected to fight. However, the Secretary of Defense, Robert Gates, has pressed the acquisition community to focus more on current needs of the current conflicts (Shachtman 2008). As depicted earlier, the MULE-T's performance in the urban and mountain scenarios was better than its performance in the jungle scenario. However, the jungle scenario is the only one of the three types of terrain in which the IBCTs are currently not deployed. Therefore, it is recommended that further analysis be done to see if the MULE-T is a viable enough solution for the theaters in which we are currently engaged.

Such a study requires analysis with a greater breadth than just the tactical implications of integration. The requisite analysis could be combined with the Maneuver Center of Excellence's plan to conduct a military utility assessment on the Squad Mission Support System in Afghanistan later in 2010. The Squad Mission Support System, which is also produced by Lockheed Martin, is a similar yet smaller system designed to carry one squad's equipment as opposed to two (Osborn 2009, 11). Although there are additional differences between the two systems, a military utility assessment which showcased varying capabilities would provide the Army with a clearer picture of what is needed to support units in theater.

A DOTMLPF analysis must precede a decision to integrate the MULE-T into a formation, whether as theater provided equipment or as an addition to the modified table of organizations. As stated in chapter 1, this research project only examined the tactical integration of the MULE-T into a small unit within the IBCT. As with any change in the force structure, further studies must be conducted across all the DOTMLPF domains. Earlier in this section, a few of the other solutions available within the materiel domain were mentioned; however, further studies are needed to expand the options available within the materiel domain and determine if there are additional solutions within the other domains. Even if other material solutions are found, the Army, in concert with the Marine Corps, must continue to focus research and development money towards lightening the load of the Soldier by reducing the weight of the equipment he carries. Any other material solution will be a mitigation strategy as opposed to a solution to the overall problem of Soldier's load weights.

If the MULE-T or any other DOTMLPF solution is chosen for integration into the force, further study must once again be conducted across the DOTMLPF domains. However, at this point the domains should be utilized to assess the overall impacts of integration of the solution upon the force. For example, if the MULE-T were fielded to an IBCT, would mechanics need to be added to the forward support companies and brigade support battalion? Do those mechanics currently have the necessary skill sets to repair large UGV? Additionally, assessments of the facilities domain will lead to issues like motor pool space and training areas to support training and sustainment at home station. These issues must be identified and addressed to understand the full scope of the challenges associated with changes in the force structure.

This section set forth three recommendations for further study. Those recommendations included analysis of alternative methods of movement, the MULE-T as theater provided equipment, and the need for a two phase DOTMLPF assessment.

Although each of these topics is both relevant and important to the Soldier's load and the MULE-T, they were beyond the scope of this research project.

Summary

In summary, this study concluded that the MULE-T, as it is currently designed, is not a viable mitigation strategy for the Soldier's load problem in the IBCT. The Soldier's load problem in the IBCT is clearly a capability gap which impacts the overall combat effectiveness of the formation. However, the MULE-T's size simply makes it too large to be integrated into a light infantry formation. Further work is required to either revise the requirements which have driven the UGV's size to its current design status or the Army must seek a different materiel solution to mitigate this dilemma. Regardless, of the mitigation strategy chosen, the Army and Marine Corp must continue to jointly endeavor to lighten the load of its Soldiers and Marines by reducing the weight of the equipment they carry to assure combat effectiveness.

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